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FISH AND WILDLIFE INVENTORY
OF THE SEVEN-COUNTY REGION

Archbold Biological Station
Contract No. 14-16-0009-77-005

Volume III 1280- A.6
Appendices

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APPENDIX A

List of data sources consulted in connection with the Fish and Wildlife Inventory of the Seven-County Region included in the Central Florida Phosphate Industry Areawide Environmental Impact Study.

Fish and Wildlife Inventory of the Seven-County Region

U. S. Fish and Wildlife Service
Contract No. 14-16-0009-77-005
APPENDICES A THROUGH G

VOLUME 3

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Appendix A. List of data sources consulted

Major Publications

(Specific papers cited in various sections of the text and additional relevant publications are included in the "Selected References" sections in the main body of the report.)

Acta Theriologica
American Birds
American Midland Naturalist
Animal Behaviour
Annual Report, Florida Geological Survey
Arthropods of Florida
Audubon Field Notes
Audubon Magazine
Auk
A.O.U. Monographs
Biological Conservation
Biological Sciences Series, University of Florida
Biota of Freshwater Ecosystems
Bird-Banding
Bird-Lore
Bulletin, American Museum of Natural History
Bulletin, Florida Geological Survey
Bulletin, Los Angeles County Museum of Natural History
Bulletin, Nature Conservancy, Florida Chapter
Bulletin, Florida State Museum
Bulletin of Marine Science
Bulletin, Museum of Comparative Zoology
Bulletin, Northeastern Birdbanding Association
Bulletin, Tall Timbers Research Station
Contributions, Mote Marine Laboratory
Copeia
Current Research, Florida Marine Research Laboratory
EBBA News
Ecological Monographs
Educational Series, Florida Marine Research Laboratory
ENFO Newsletter
Endangered Species Technical Bulletin, U.S. Department of the Interior
Everglades Natural History
Evolution
Fishery Bulletin
Florida Conservation Digest
Florida Conservation News
Florida Entomologist
Florida Field Naturalist
Florida Game and Fresh Water Fish Commission Annual Report
Florida Marine Research Publications
Florida Naturalist
Florida Scientist

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Florida State Museum Newsletter
Florida Wildlife
Herpetologica
Information Circular, Florida Geological Survey
Journal of Herpetology
Journal of Mammalogy
Journal of Wildlife Diseases
Journal of Wildlife Management
Leaflet Series, Florida Marine Research Laboratory
Living Bird
Mammal Review
Marine Mammal Newsletter
Memoirs of the Hourglass Cruises
Miscellaneous Publications, Florida Marine Research Laboratory
Miscellaneous Publications, Tall Timbers Research Station
Mote Marine Laboratory Newsletter
Nature Magazine
North American Fauna
Novitates, American Museum of Natural History
Oecologia
Plaster Jacket, Florida State Museum
Proceedings, Annual Conference Southeastern Association of Game and Fish Commissioners
Professional Papers Series, Florida Marine Research Laboratory
Quarterly Journal, Boston Zoological Society
Quarterly Journal, Florida Academy of Sciences
Raptor Research Foundation Information Exchange
Raptor Research
Report of Investigations, Florida Geological Survey
Special Scientific Report, Florida Marine Research Laboratory
Systematic Zoology
Technical Series, Florida Marine Research Laboratory
Transactions, North American Wildlife and Natural Resources Conference
Tulane Studies in Zoology and Botany
Wildlife Research Report, U. S. Fish and Wildlife Service
Wilson Bulletin
Zoologica

Federal Agencies

Environmental Protection Agency
    Eugene McNeill

National Marine Fisheries Service
    William Lindall, St. Petersburg
    J. Ernest Snell, Supervisory Fishery Reporting Specialist, Miami

National Oceanic and Atmospheric Administration

Soil Conservation Service
    I. H. Stewart

U. S. Army Corps of Engineers
  Dorothy Booth, Environmental Effects Laboratory
  John Hussey, Jacksonville District

U. S. Department of Agriculture Forest Service

U. S. Geological Survey

U. S. Fish and Wildlife Service
  James Barkuloo, Office of Biological Services, Panama City
  John W. Baumeister, Land and Water Resource Development Planning, Atlanta, Georgia
  Danny Bystrak, Migratory Bird and Habitat Research Laboratory, Laurel, Maryland
  Howard Campbell, National Fish and Wildlife Laboratory, Gainesville Station
  Joe Carroll, Vero Beach
  Steven P. Christman, National Fish and Wildlife Laboratory, Gainesville Station
  Blair Irvine, National Fish and Wildlife Laboratory, Gainesville Station
  Joe Johnston, Vero Beach
  James B. Kirkwood, Coastal Ecosystems, Atlanta, Georgia
  William K. Lindsay, Coal/Minerals Regional Activity Leader, Atlanta, Georgia
  L. Arch Mehrhoff, Project Leader-Office of Biological Services, Boise, Idaho
  David W. Peterson, Florida Southern Bald Eagle Survey Team, Gainesville
  Howard Poitevint, Vero Beach
  Herbert B. Quinn, Jr., Upland Ecosystems, Washington, D. C.
  Porter B. Reed, Jr., Wetlands Office, St. Petersburg
  Lorna Sicarello, Vero Beach
  Paul W. Sykes, Jr., Endangered Wildlife Research, Delray Beach
  Donald W. Woodard, National Coastal Ecosystems Team, Mississippi

U. S. Fish and Wildlife Reference Service

U. S. Fish and Wildlife Service Waterfowl Harvest Surveys

State Agencies

Bureau of Geology

Department of Air and Water Pollution

Department of Agriculture and Consumer Services
  Howard V. Weems, Jr., Bureau of Entomology
  Robert E. Woodruff, Bureau of Entomology

Department of Environmental Regulation
  Alan Burdett, St. Petersburg
  Rick H. Cantrell, Punta Gorda
  Gerald Hardy, Tallahassee
  Landon T. Ross, Tallahassee

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Department of Health and Rehabilitative Services
- William J. Bigler, Disease Control Program
- Gerald L. Hoff, Disease Control Program
- Flora Mae Wellings, Epidemiology Research Laboratory

Department of Natural Resources
- Kenneth C. Alvarez, Division of Recreation and Parks
- Dannie A. Hensley, Marine Research Laboratory
- Bruce Johnson, Bureau of Coastal Zone Planning
- Gale Lyon, Gulf of Mexico Regional Fishery Management Council
- John R. Squire, Division of Recreation and Parks
- James A.Stevenson, Division of Recreation and Parks
- Mary Lou Stursa, Bureau of Coastal Zone Planning
- George Wilson, Division of Recreation and Parks

Department of Pollution Control

Department of Transportation

Division of State Planning
- Keith Maw

Florida Game and Fresh Water Fish Commission
- David H. Austin, Avon Park Wildlife Management Area
- Jerry Banks, Fish Management Division
- James R. Brady, Wildlife Research Laboratory
- Major J. O. Brown, South Florida Region
- Phil Chapman, South Florida Region
- Edwin J. Conklin, Wildlife Management Division
- Dan Dunford, Bureau of Environmental Protection
- Steven B. Fickett, Jr., Brooksville
- D. Terry Gilbert, Bureau of Environmental Protection
- Vincent Guillory, Orlando
- Tommy Hines, Gainesville
- Smokey Holcomb, Eustis
- George Horel, South Florida Region
- Fred Langford, South Florida Region
- Frank Montalbano, South Florida Region
- Stephen A. Nesbitt, Wildlife Research Laboratory
- Robert Owens, License and Permit Bureau
- Fred W. Stanberry, Wildlife Management Division
- Forrest J. Ware, South Florida Region
- Lovett E. Williams, Jr., Wildlife Research Projects
- John W. Woods, Fisheries Research and Management

Planning Councils and other County Agencies

Central Florida Regional Planning Council (Fred Kenetski, George L. Stansbury)

Charlotte County Regional Planning Council (Terry F. Hixson)

DeSoto County Zoning and Planning Department (Bud Shaeffer)

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Hardee County Commissioners' Office (Vida Tomlinson)

Manatee County Planning and Development (Douglas Widmer)

Polk County Planning Council (Michael Joachim)

Sarasota County Planning Council (Dennis B. Wilkison)

Southwest Florida Regional Planning Council (Wayne Daltry)

Tampa Bay Regional Planning Council (Charles E. Howell, Jan Parkinson)

Other Organizations

Bromwell Engineering (Leslie G. Bromwell, Richard Malavenda)

Conservation Consultants, Inc. (Gary J. Montin, Lawrence J. Swanson, Jr.)

Florida Phosphate Council

General Development Corporation (William Wilcox)

Mote Marine Laboratory

Southwest Florida Water Management District (William Courser)

Tampa Electric Company (William J. Johnson)

Texas Instruments, Inc. (Larry G. Bowles, Noel Cutwright, Roy Greer, Audrey M. James)

Tri-County Engineering, Inc.

Audubon Societies

National Audubon Society (John M. Anderson)

Florida Audubon Society (Alex Friedman)

Within seven-county area

Lake Region Audubon Society
Manatee County Audubon Society
Miakka Audubon Society
Ridge Audubon Society
Sarasota Audubon Society
Sun City Center Audubon Society
Tampa Audubon Society
Venice Area Audubon Society

Adjacent to seven-county area

Clearwater Audubon Society
Highlands County Audubon Society
St. Petersburg Audubon Society
Sanibel-Captiva Audubon Society

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Other Conservation Organizations

Caretta Research, Inc. (Charles R. LeBuff, Jr.)
Environmental Confederation of Southwest Florida (Roy E. Bazire)
Florida Conservation Council
Florida Conservation Foundation
Florida Defenders of the Environment
Florida Wildlife Federation
Florida Wildlife Sanctuary (Carlton O. Teate)
Hillsborough Wildlife Association
Manasota 88
Nature Conservancy
Sanibel-Captiva Conservation Foundation (Richard W. Workman)
Save Our Bays Association (Sally Thompson)
Suncoast Sierra Club
Tampa Bay Group Sierra Club

Libraries

American Museum of Natural History
Florida A & M University (Nicholas E. Gaymon)
Florida Atlantic University
Florida State University (Marianne Donnell)
Mote Marine Laboratory (Patricia Morrissey)
Rosenstiel School of Marine and Atmospheric Sciences
University of Florida (Virginia Francis)
University of Miami
University of South Florida (Mary A. Sepanik)
University of Tampa (Lydia M. Acosta)

[redacted]

Museum and other collections (groups surveyed in parentheses)

- American Museum of Natural History (amphibians, reptiles, birds, mammals)
  - Alexander R. Brash
  - Roger F. Pasquier
  - Lester Short
  - Richard G. Zweifel

- Archbold Biological Station

- Carnegie Museum of Natural History (amphibians, reptiles, birds)
  - C. J. McCoy
  - Kenneth Parkes

- Chicago Academy of Sciences (fishes, amphibians, reptiles, birds, mammals)
  - William Beecher

- Cornell University (fishes, birds, mammals)
  - Roland Bauer
  - William Conner

- Field Museum of Natural History (amphibians, reptiles, mammals)
  - Jonathan C. Fox
  - Paul Gritis
  - Hyman Marks
  - Robert E. Martin

- Florida Atlantic University (fishes)
  - Walter R. Courtenay, Jr.
  - Stephen R. Lau

- Florida State Museum (fishes, amphibians, reptiles, birds, mammals)
  - Walter Auffenberg
  - Carter Gilbert
  - J. W. Hardy
  - Stephen R. Humphrey
  - Pat Piersol
  - Sarah Sloane
  - Mark Wygoda

- Florida State University (fishes, amphibians, reptiles, birds, mammals)
  - Hal A. Beecher
  - Ralph W. Yerger

- Florida Technological University (fish, amphibians, reptiles, birds, mammals)
  - Llewellyn M. Ehrhart
  - Richard A. Seigel

- Harvard University Museum of Comparative Zoology (amphibians, reptiles)
  - Patricia G. Haneline

Louisiana State University Museum (fishes, amphibians, reptiles, birds, mammals)
    John P. O'Neill

National Museum of Natural History (amphibians, reptiles, birds, mammals)
    Stephen Busack
    Barbara Harvey
    Katherine Pruitt
    George Watson

North Carolina State Museum of Natural History (amphibians, reptiles, birds, mammals)
    Alvin L. Braswell
    John B. Funderburg
    David S. Lee

Texas Tech University (mammals)
    Pat Dolan
    Jane Groen

Tulane University Museum of Natural History (fishes)
    Royal Suttkus

University of Miami (amphibians, reptiles, birds, mammals)
    Leonard J. Greenfield

University of Michigan (amphibians, reptiles, birds, mammals)
    Michael D. Carleton
    Adrian F. Czajka
    John F. Douglass
    J. G. Strauch

University of South Florida (fishes, amphibians, reptiles, birds, mammals)
    John C. Briggs
    Larry N. Brown
    J. Steven Godley
    Roy W. McDiarmid
    Glen E. Woolfenden

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Robert L. Buckbee, Arcadia
George W. Cornwell, EcoImpact, Inc.
Bruce C. Cowell, Department of Biology, University of South Florida
Thomas Cross, Earth Metabolic Design Laboratory, Sarasota
John F. Dequine, Southern Fish Culturists, Inc., Leesburg

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Frank Dunstan, National Audubon Society, Tampa
John B. Edscorn, Lakeland
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Ernest Estevez, Department of Biology, University of South Florida
G. B. Fairchild, Department of Entomology and Nematology, University of Florida
Thomas H. Fraser, Environmental Quality Laboratory, Port Charlotte
John B. Funderburg, North Carolina State Museum of Natural History, Raleigh
William A. Ganter, Production Automation, Inc., Boulder, Colorado
Carter R. Gilbert, Florida State Museum, Gainesville
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William Heard, Department of Biological Sciences, Florida State University
Robert S. Hearon, International Minerals and Chemicals, Bartow
David H. Hirth, School of Forest Resources and Conservation, University of Florida
Horton Hobbs, Smithsonian Institution, Washington, D.C.
Bobbie Kittleson, Lakeland
David S. Lee, North Carolina State Museum of Natural History, Raleigh
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Skip Livingston, Department of Biological Sciences, Florida State University
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Bruce Means, Tall Timbers Research Station, Tallahassee
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Jonathan Miller, Naturalists, Sarasota
Blanche Mink, Englewood
John Morrill, Environmental Studies Program, New College
Julie Morris, Naturalists, Sarasota
Kenneth D. Morrison, Mountain Lake Sanctuary, Lake Wales
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Chester E. Winegarner, Archbold Biological Station
Sandy Young, Bioresearch, Tampa

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APPENDIX B

A report on potential effects of phosphate mining on estuaries of the seven-county area

Prepared by

Julie Morris and Jonathan Miller

The Naturalists

Sarasota, Florida

July 1977

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I. DESCRIPTION

WATERSHEDS

The State of Florida Hydrologic Unit Map (U.S.G.S., 1974) reveals that the seven counties comprising the phosphate study area include portions of 15 river and coastal creek systems. These 15 watersheds contribute to a wide variety of estuaries arrayed around the peninsula (Fig. 1). The Green Swamp and Lake Okeechobee represent natural and engineered "roundhouses" respectively - surface water can move in a multiplicity of directions from these areas.

In an effort to identify those watersheds and estuaries that may be directly affected by existing or planned phosphate mining operations, we compared a number of sources (Map 1) of information related to the location of phosphate deposits in the seven county study area. Having concluded that the extent of "relevant" phosphate deposits is a function of geologic sophistication and economics, we settled on a 1976 map of property owned by phosphate or chemical companies (SWFWMD, 1976).

The outermost holdings on the SWFWMD map show a remarkably good correlation with the approximate boundary of calcium phosphate zone as mapped by USGS (1967)(Fig. 2). Their calcium phosphate line was taken from Cathcart and Lawrence (1959) appears to be, for the time being, an accurate limit for speculative phosphate land purchases in the near future. Graphic analysis suggests that current phosphate holdings lie in parts of seven watersheds that flow into three estuaries - Withlacoochee Bay, Tampa Bay, and Charlotte Harbor.

This work does not treat the Withlacoochee river drainage and estuary due to its vast size, unique hydrologic characters, and relative isolation from the other watersheds studied. It is also underlain in areas by hard rock phosphate which may complexify the issue even further.

ESTUARIES

What is an estuary?

An estuary is "A semienclosed body of water which has free connection with the open sea and within which sea water is measurably diluted by fresh water from land drainage" (Cronin et al., 1971). Each estuary is an ecosystem, different from other estuaries on the basis of the local characteristics of its river(s) sea, land, and air. Certain estuarine traits are exemplified by both Charlotte Harbor and Tampa Bay estuaries that are also common to many estuaries of the Gulf and Atlantic coasts.

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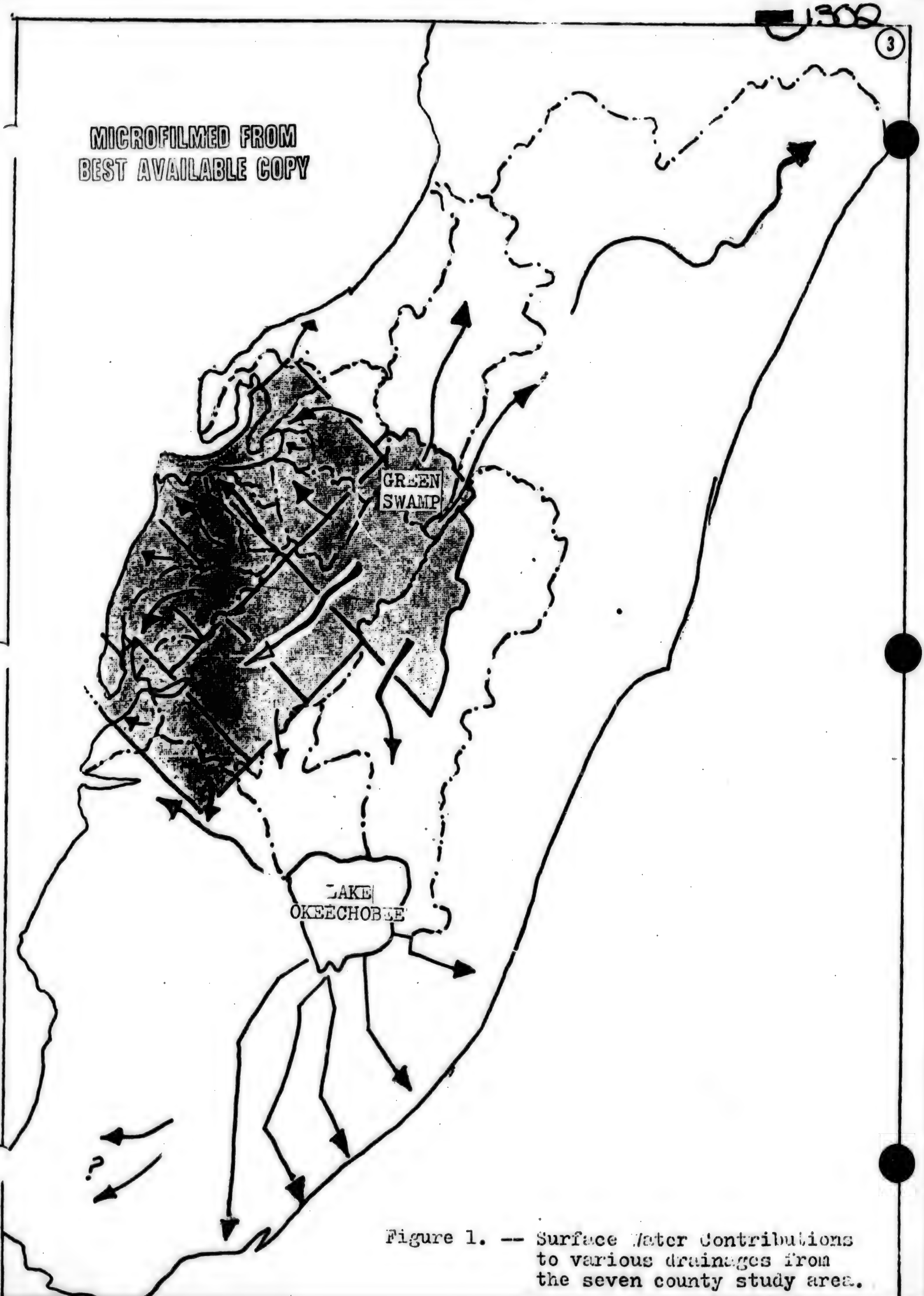

Figure 1. -- Surface Water Contributions to various drainages from the seven county study area.

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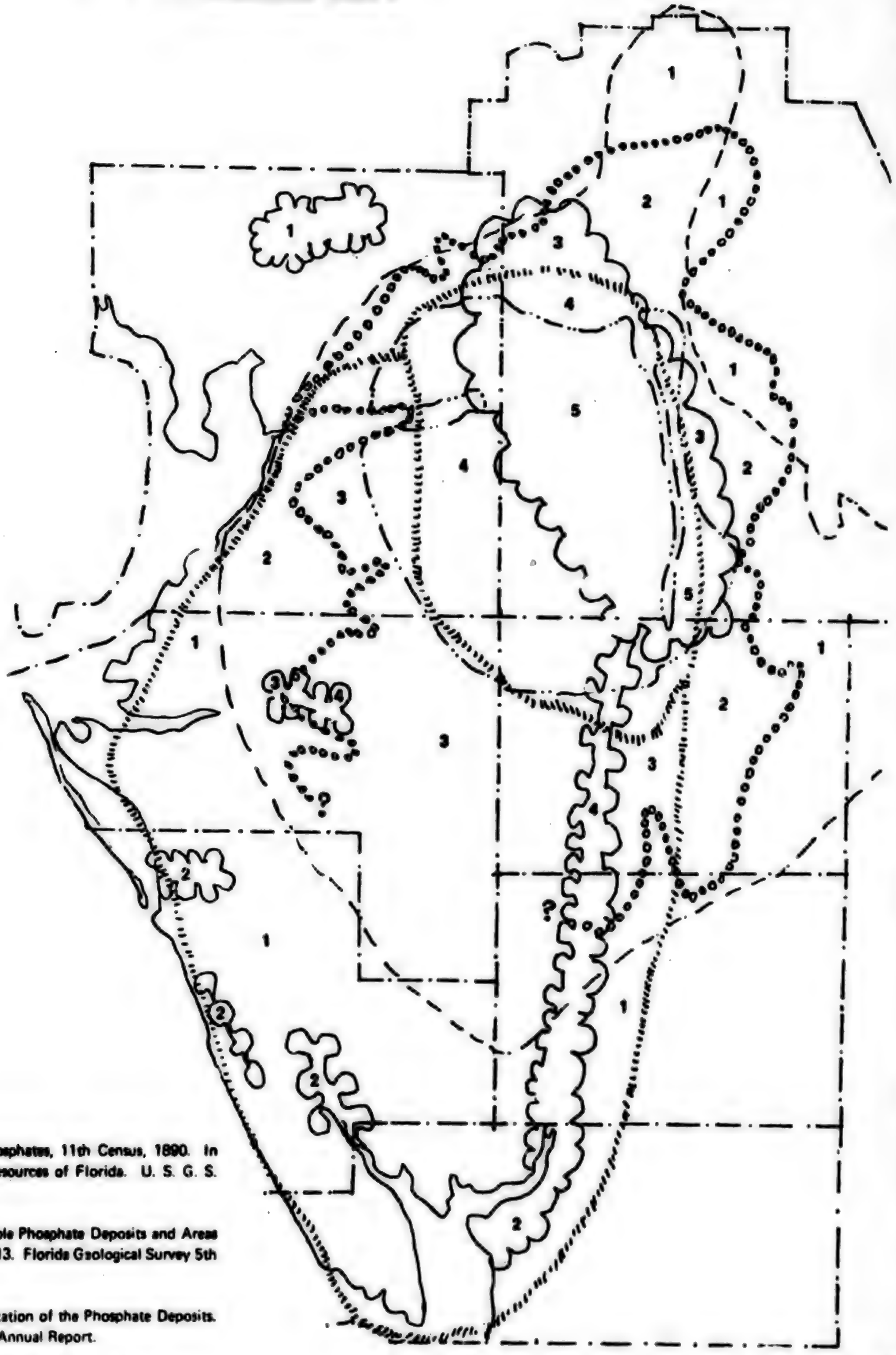

1890 from Map of Florida showing regions of phosphates, 11th Census, 1890. In Mansfield, G. R. 1942. Phosphate Resources of Florida. U. S. G. S. Bull. 934.

1913 from Topography, Hard Rock and Land Pebble Phosphate Deposits and Areas of Artesian Flow. In Sellards, E. H. 1913. Florida Geological Survey 5th Annual Report.

1915 from Sketch Map of Florida showing the Location of the Phosphate Deposits. In 1915. Florida Geological Survey 7th Annual Report.

1943 from Key Map to Mineral Resources of Florida. In Vernon, R. O. 1943. Florida Mineral Industry, with summaries of production for 1940 and 1941. Fla. Bu. Geo. Bull. 24.

1959 from Location of Sampling Sites on streams and area of phosphate mining and processing. In Toler, L. G. 1967. Flouride in Water in the Alafia and Peace River Basins. Fla. Bu. Geo. Report of Investigations No. 46.

Map 1. – Various Estimates of Phosphate Deposits.

Numbers represent the number of maps (out of 5) that suggest phosphate is found in a given area.

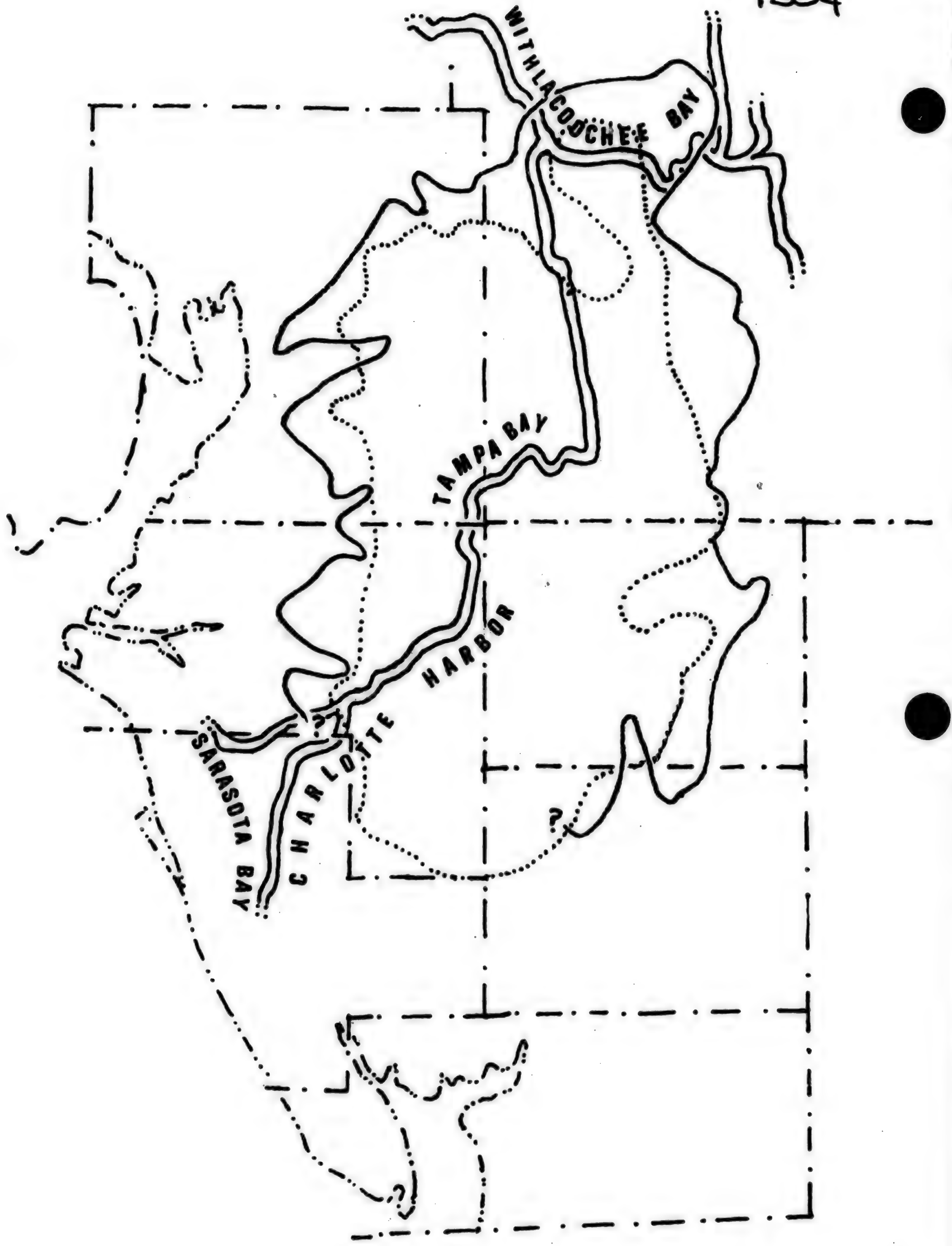

Figure 3. -- Relevant Phosphate Holdings and Watersheds

∼ Calcium phosphate zone (from Toler, 1967)

…… Generalized boundaries of current phosphate land holdings (from SWFWMD, 1976)

═ Watershed divides (from U.S.G.S., 1974)

The salinity of our estuaries varies from seawater concentrations of 30-35 parts per thousand (0/00) to freshwater - 0 ^{0}/oo. The salinity of water at a fixed point in an estuary can vary daily between ebb and flood tides, and seasonally from the amount of rainfall flowing into the estuary from its rivers.

In the Northern Hemisphere, because of the rotation of the earth, high salinities reach farther up the right hand side, facing upstream, of estuaries. This phenomenon is illustrated by surface salinity distribution figures compiled by Alberts et al. in 1970 for Charlotte Harbor. (Fig. 3).

Deeper waters in estuaries are saltier than surface waters, resulting in a wedge of saltier water that extends far upstream along the bottom and, comparably, a wedge of fresher water that extends far downstream at the surface. This is also illustrated in a "3 dimensional" figure of isohalines in Charlotte Harbor (Alberts et al., 1970) (Fig. 4).

Finally, a two layered circulation is known to occur in estuaries wherein the fresher surface waters, though ebbing and flooding with the tide, have a net downstream movement, while the saltier deep waters have a net upstream movement. Many estuarine organisms utilize these circulation patterns at different stages of their life histories to move either toward the sea or toward the river (Cronin et al., 1971).

Besides freshwater, rivers contribute suspended sediments to the estuaries. On Florida's West Coast, rivers add large sediment loads to the estuary only during flood stage periods. Highest concentrations of suspended sediments occur in the low salinity portions of the estuary. Higher salinities (any higher than 5 ^{0}/oo)(Huang & Gooddel,1967) cause the sediments to flocculate, and slow water velocities allow sediments to settle out. Sediments containing high percentages of silt and clay (river related sediments) are found near the mouths of major tributaries. Sediments that settle out in shallow areas are often resuspended by wave action, while those that settle in deeper channels remain, unless dredging resuspends them.

Estuaries have higher annual production and are far richer in nutrients than the Gulf or the freshwater upstream. The majority of the suspended sediments received by an estuary are silts and clays, which have a great sorptive capacity for dissolved nutrients, and these nutrients become stored in the sediments. The downstream flow of fresher surface waters, and the upstream movement of deeper saltier waters creates a circulation pattern within the water column which traps suspended nutrients in the estuary. Pomeroy (1965) found that as

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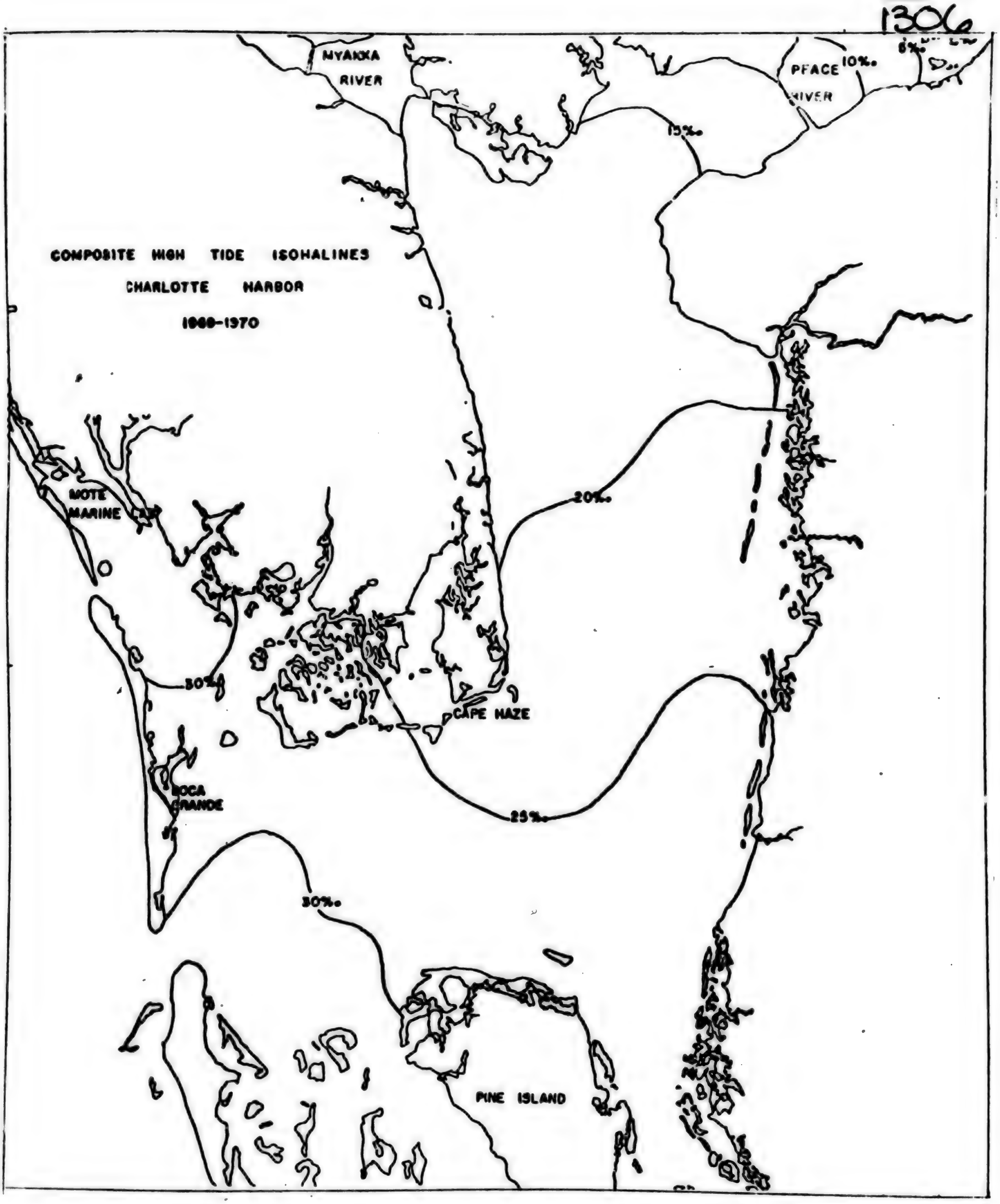

Figure 3. -- From Alberts et al.,1970

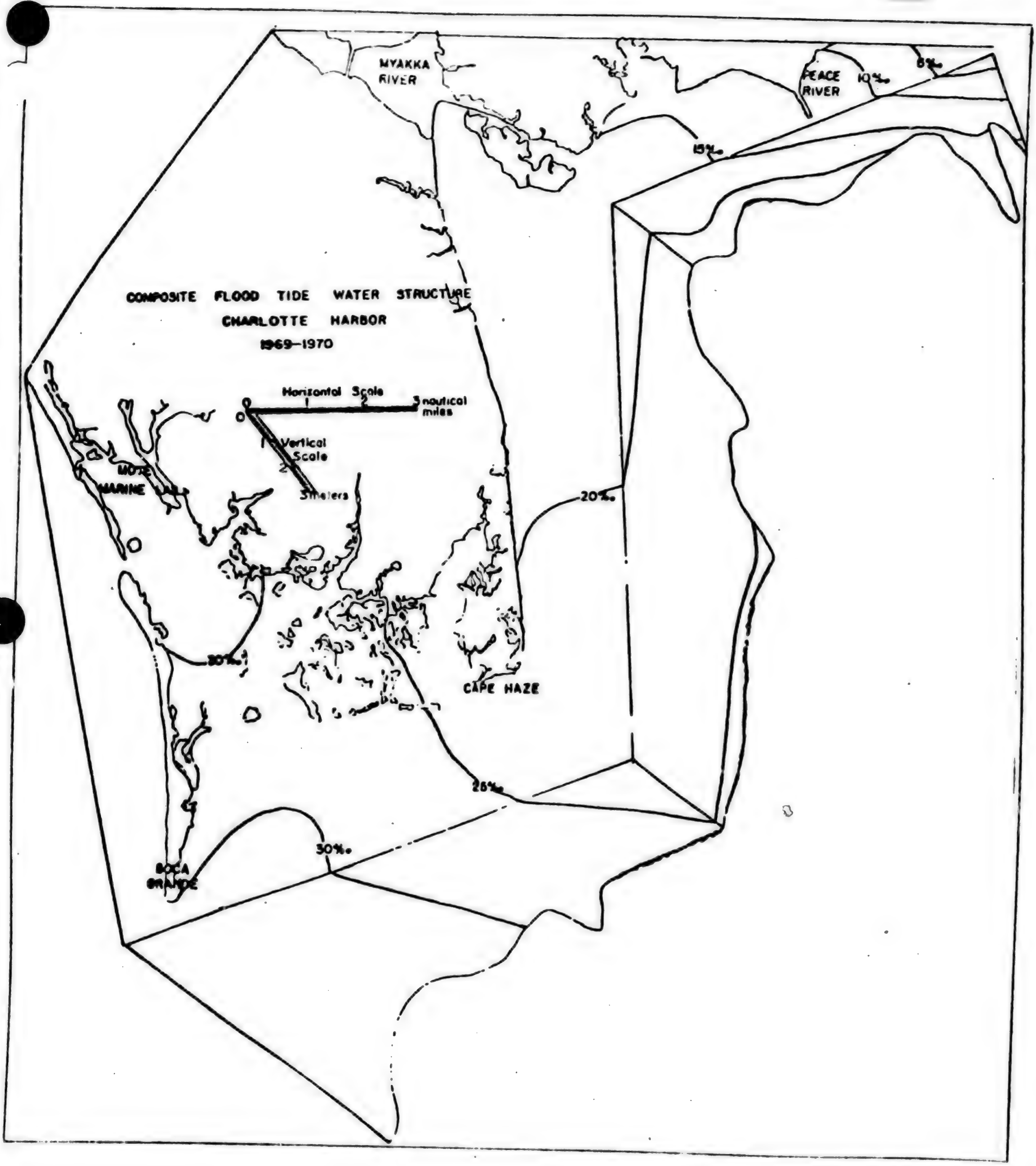

Figure 4. -- From Alberts et al., 1970

phosphorous is removed from water by phytoplankton and bacteria, it is replaced by phosphorous desorbed from the sediments into the water.

Filter feeders, molluscs and crustaceans ingest large amounts of suspended particles and extrud them as fecal pellets which settle out on the sediments, effectively pumping suspended nutrients into the sediments.

Nutrients stored in estuarine sediments are accessible to rooted plants and burrowing organisms, as well as to the water column as mentioned earlier, through desorption.

Great numbers of estuarine organisms ingest sediment particles directly, and since estuarine sediments trap pollutants as effectively as nutrients, contamination enters the food webs readily, and in the case of filter feeders, is readily concentrated.

". . .Physiologically, estuaries are stress habitats which strongly challenge their inhabitants as well as potential new immigrants. . . .
Ecologically, most estuaries represent zones of reduced competition and thus may serve as refuges for organisms which have a great potential for compensating ill effects of physico-chemical properties of their environment, (can endure wide ranges of salinity, temperature, oxygen, and other abiotic factors), but at the same time, have a small potential for competition (insufficient devices for protection and escape from predators, parasits, etc., and low rates of reproduction") (Kinne, 1966). Juvenile fish often inhabit low salinity waters and move out to more saline water as they mature. The juveniles can physiologically tolerate low salinity, but are quite vulnerable to predators. Generally, predators cannot tolerate low salinity and the estuary provide sanctuary and nursery ground for the juveniles.

Wang and Raney (1971) found a high abundance of euryhaline forms and juveniles of many species near the mouths of the Peace and Myakka Rivers in their fish studies of the Charlotte Harbor area. They state that these "small estuarine species play a very important role in supplying a future stock of adults of their own species, and as the food of other species. It can be safely predicted that conditions which adversely affect these small fishes will do considerable damage to Florida's commercial and sport fishing industries."

Four plant communities provide primary productivity for the estuary. Three of these contribute primarily to the detritus food webs, and provide essential habitat as well. They are mangrove, salt marsh, and seagrass beds. Phytoplankton communities, in contrast to the other three, are grazed directly by zooplankton.

[redacted]

Organic plant material produced by seagrass, mangrove litter, or marsh plants, forms the basis for the detritus food webs of the estuaries. As dead plant material enters the water it becomes cloaked with bacteria and fungi, the decomposers, and protozoa which graze on the bacteria. Together with its microorganisms, the plant material has become detritus, and is the principal food, along with small amounts of algae, for herbivorous and omnivorous crustaceans, molluscs, insect larvae, nematodes, and several fishes. Many of these primary consumers digest only the outer layer of microbial protein, and expel the detrital particle. The particles can be recolonized and eaten many times until they become quite small in size and are either seized by filter feeders or bound with other fine particles into new, larger aggregate particles.

The pink shrimp Panaeus duirorum and the striped mullet, Mugil cephalus, two commercially important fisheries on Florida's Gulf Coast, are principally detritus consumers.

MANGROVES

Mangroves are a group of taxonomically diverse species of trees with a common habit -- they can grow in low-energy intertidal areas. There are three species of trees that fit this description in Florida: red mangrove Rhizophora mangle, black mangrove Avicennia nitida, and white mangrove Laguncularia racemosa. A fourth species, buttonwood Conocarpus erecta, tends to grow on higher land than the others and is treated differently by different experts.

The sumtotal of the individual and collective roles mangroves play is not fully known - the reds being the most extensively studied species at this point in time. The known functions of mangroves include: wave and wind energy dissapators, nutrient sinks, land builders, habitat providers, and litter producers (Humm, 1973a).

The leaf litter that falls from red mangroves has been extensively studied and reviewed by Heald, Odum, and Tabb (1974). When leaves and other plant material fall from the tree they are invaded by microbes and physically, chemically, and biologically broken down into small detrital particles. In the course of a year the percentage of protein in a fallen red mangrove leaf can quadruple as a result of this microbial activity.

The small leaf particles are fed upon by a wide variety of primary consumers, including striped mullet, Mugil cephalus and pink shrimp Penaeus duorarum. McNulty et al., (1972) found these two species to be the most economically important species landed on the southwest coast of Florida. As was noted earlier, the leaf particle can be recolonized and reconsumed many times.

[redacted]

Larval fish, juvenile fish, and small adult fish such as Killifish feed on the many crustacean, fish, and polychaete primary consumers. These lower consumers are consequently eaten by middle carnivores such as snook, spotted seatrout, red drum, jewfish, and wading birds. According to Heald et al. (1974) "virtually all the important sport fish and most commercially important species, are basically carnivorous and depend, directly or indirectly, on the omnivorous or herbivorous primary consumers. . . ."

Top carnivores such as tarpon, bull shark, bald eagles, and ospreys feed on middle carnivores and mullet. The role of more isolated areas of the mangrove forest is less understood and more subject to debate. It is known that the leaves fall and that there is less opportunity for them to be washed into the estuary, but there is not agreement on the ecological magnitude and meaning of frequency of flushing of the higher mangrove forests. It is known that occasionally flooded forests support large numbers of salt water mosquitoes which are fed on by specialized fishes such as Gambusia affinis and Fundulus confluentus. They are eventually concentrated by falling water levels and fed on by wading birds.

Woolfenden and Schreiber have concluded that mangroves "are absolutely essential to the existence of a large number of water birds that breed in Florida, for essentially all of the breeding colonies of pelicans, cormorants, herons, and ibises of saline environs are in mangrove. Not only does mangrove supply breeding sites, but also the nutrients necessary early in the food webs that lead to the items taken as prey by birds. (1973)."

Heald et al. (1974) stress the importance of flushing action for maximum mangrove productivity and benefit. ". . . the detritus-based food web described above is dependent to a large extent upon fresh water flow or on relatively strong tidal action. Walsh (1967) and Craighead (1971) point out that the largest and most vigorous mangrove stands are always associated with riverine conditions. Studies by Lugo, et al. (1973) indicate a heavy dependence by mangroves on primary nutrients transported from upland terrestrial sources by river water."

TIDAL MARSH

While it may be said that the functioning of tidal marshes is roughly analagous to the functioning of mangroves, no one is in a position to say exactly how analagous they are on the central barrier coast of Southwest Florida.

They are both estuarine systems of relatively high primary productivity in which grazing on live plant material is minimal and there is no direct harvest by man. Dead plant material in both systems travel along one of three routes - it is stored as peat, recycled in the community, or exported into the estuary in the form of detrital particles that form much of the basis of the enormously productive estuarine food web. In the absence of tidal or other flushing, organic material builds up in both systems.

A general comparison of the distribution of tidal marsh and mangroves leads one to hypothesize that tidal marshes are temperate analogs of the tropical mangroves. The severe frosts of early 1977 have certainly limited the advance of mangroves up the tidal creeks and rivers of the Southwest coast of Florida. The salt marshes persist, nevertheless, into the everglades where Craighead believes they have replaced fresh-water sawgrass marsh (Heald, 1971). Heald describes the black rush (*Juncus romerianus*) marshes of the North River as transitional zones between the mangrove and sawgrass communities.

In the estuaries of the seven county phosphate study area, *Juncus* marsh appears to occupy riverine zones intermediate between the upriver freshwater association of *Spartina bakeri* and *Typha* and the mangroves of the more saline (and warmer) estuaries.

The productivity of tidal marsh varies widely from estuary to estuary and within the estuaries depending on species composition, growing season, nutrients and other factors. The tidal marshes in the study area lie between two of the most productive tidal marsh areas known - Barataria Bay, La. and the coastal marshes of Georgia. Both these marshes are composed almost solely of *Spartina alterniflora* the predominant intertidal flowering plant from Newfoundland to Texas, except in Mississippi and Florida where *Juncus roemerianus* and mangroves (Florida) increase (Lewis and Dunstan, 1975). Kurz and Wagner, according to Lewis and Dunstan (1975) and McNulty et al. (1972) believe that Juncus predominates in Florida and that the Juncus is found at slightly higher elevations than *S. alterniflora.* Lewis and Dunstan have shown that *Spartina* marshes on spoil in Tampa Bay can be successfully colonized by mangrove seedlings. If *S. alterniflora* is found to generally represent a seral stage preceeding mangroves on this coast, then the persistant tidal marshes of the study area will be the *Juncus* marshes.

Relatively little is known about the *Juncus* marshes that lie along rivers and creeks on this coast. Any discussion of the function of *Juncus* in the estuaries of the seven county study area is primarily "interpolation" between the role of mangroves in this area and the nature of *Juncus* elsewhere.

It is generally agreed on that the amount of fallen mangrove material that ends up as peat relative to the amount that enters the estuary as detritus is a function of flushing. What is not agreed upon is at what magnitudes and frequencies mangroves cease to make important contributions to the estuaries. The Juncus marsh seems susceptible to the same arguments.

Juncus is notoriously slow to decompose. Heald (1971) found that only 35 to 45 percent of the original weight was lost in 13 months. This fact alone would seem to predispose Juncus towards the accumulation of peat rather than the production of exported detritus. Still, if the material that decomposed was flushed to the estuary, the Juncus marsh would be competitive with Spartina - 45 percent of net production exported out of the marsh (Humm, 1973). Heald found that 38 percent of Juncus debris would be reduced to detritus in 12 months. Heald ultimately concluded that Juncus marshes were unimportant debris producers when compared with the mangroves of his study area.

It may be that the nutrient sink function of tidal marshes is more important than their detrital contribution.

Steever et al. (1976) have found a strong positive correlation between tidal range and standing crop biomass in tidal marshes along the Connecticut shoreline. They suggest that increased circulation increases nitrogen availability and consequently production. Day et al. (1973) state that most evidence points to nitrogen as the primary limiting nutrient in estuarine systems. Patrick and Delaune (1976) added nitrogen to marshes in Barataria Bay, La. and increased yield by 15 percent. The addition of supplemental phosphate had no effect on productivity. This recent work on the functioning of tidal marsh suggests that the marshes function as "nitrogen sponges" -- with the capacity to soak up nitrogen in excess of what they normally receive.

In addition to their functions as nutrient and sediment sinks, and detritus and peat producers, Humm (1973b) and Taylor et al. (1973) agree on the following functions: tidal marshes function as surge tanks that dampen riverine or tidal flow pulses, and tidal marshes provide important habitat, especially for invertebrates and birds.

Woolfender and Schreiber (1973) have characterized the tidal marshes of the eastern Gulf of Mexico as follows: "Dredge and fill operations have eliminated much of this important Gulf coastal habitat, which not only supports its own avifauna of rails, sparrows, ducks, and numerous shorebirds, but also is the hatchery for vast numbers of fishes and invertebrates which, as they grow, move into other habitats where they form links in food webs that often lead to birds."

SEAGRASS BEDS

Six species of flowering plants are found in seagrass beds in Charlotte Harbor and Tampa Bay. *Thalassia testudinum,* Turtle Grass, is the most abundant species of the Eastern Gulf of Mexico (Humm, 1973c). It grows from the mean low spring tide line down to depths of 20 feet or more, depending on the clarity of the water. *Syringodium filiforme,* Manatee Grass, often occurs mixed with *Thalassia,* having a similar water depth distribution. Both *Thalassia* and *Syringodium* prefer clear water with salinities close to those of seawater. *Diplanthera wrightii,* Shoal Grass, tolerates wide ranges of salinity, exposure to air, turbulence and currents far better than the other seagrasses. It is a colonizer of disturbed areas, and grows as high as the mean low water line in estuaries. *Halophila ballonis* and *H. engelmanii* are relatively uncommon. *Ruppia maritima,* widgeon grass, forms extensive beds in some shallow areas of Tampa Bay.

Humm, (1973) summarizes the environmental roles of sea grass beds in estuaries as follows:

1) Seagrasses trap and stabilize bottom sediments.

2) They carry on basic productivity which may exceed the productivity of benthic algae of the same area, or of the plankton in the overlying area. Jones (1968) estimated at best, *Thalassia* beds in the Miami area fix 900 grams/m^2/ year.

3) Seagrasses provide food directly to Manatees, sea turtles, sea urchins and herbivorous fish. Decomposing leaves are eaten by many detritus feeders.

4) Seagrass beds provide refuge and a source of food organisms for juvenile shrimp, crabs, and fishes.

5) Seagrass beds provide an important substrate for attachment or many species, including a significant biomass of benthic algae.

Sea urchins depend heavily on *Thalassia* for food. Manatee and sea turtle populations have declined greatly on Florida's coast, so that besides urchins there are few direct seagrass grazers. Most of the organic matter produced by seagrasses is decomposed by bacteria and fungi, contributing to the detritus food chains.

Continuous turbidity greatly reduces the photosynthetic ability of seagrasses, especially *Thalassia*. Copeland, according to Odum (1970) found that by reducing sunlight reaching Thalassia communities, Thalassia was replaced by bluegreen algaes in dominance. Productivity of the two communities is equivalent, but bluegreen algaes are difficult to digest, and provide food and detritus to only a few species.

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Many benthic algaes characteristic of seagrass beds in the intertidal zone, are present only during the winter and spring. Several species of benthic algae respond to sewage effluents and other added nutrients with exceedingly abundant growth. These are notably Ulva lactuca, Enteromorpha, and Gracilaria foliifera (Humm, 1973c).

PHYTOPLANKTON

Phytoplankton productivity in estuarine waters is not as great as that of other primary producers, but it is essential in the food web including larval fish. Larval fish require certain amounts of small zooplankton in their diet, and these zooplankton feed on suspended algal cells. Generally, phytoplankton are most abundant in the upper reaches of Gulf coast estuaries, where inflowing fresh water carries greater amounts of suspended and dissolved nutrients. Zooplankton variety decreases with decreasing salinity, and is highest in the warm summer months in Tampa Bay (Hopkins, 1973). Charlotte Harbor zooplankton abundance is highest in September and October (Taylor, 1974). Planktonic communities are highly dynamic, moving up and downstream with the interface between nutrient laden freshwaters and saltwaters.

Estuaries experience seasonal productivity drops as well as changes in salinity during heavy rainfall events that can prove catastrophic to estuarine organisms. In June of 1968, freshwater was found in Charlotte Harbor as far south as Cape Haze (Wang & Raney, 1971). Nutrients stored in the sediments and the importance of detritus as a food source serve to buffer the effects of such major changes. "Organic detritus represents a major storage, transport, and buffer mechanism for the estuarine ecosystem: STORAGE - organic matter produced at one time is released later; TRANSPORT - downstream away from the point of production; and BUFFER - availability during seasons of low primary productivity." (Darnell, R.M., 1967).

The complex life histories of estuarine fish and shellfish exhibit developmental stages that are dependent on specific habitats and food sources provided by the interaction of salt and fresh waters and the various plant communities of estuaries.

For example, oysters, Crassostrea virginica, form benthic communities which are an outstanding feature of Florida Gulf Coast Estuaries. Oysters can tolerate high concentrations of sediments in suspension, wide temperature variations, and salinities from 5 ‰ to seawater concentrations. However, oysters are usually found in low salinity portions of the estuary, because of the many oyster parasites and predators that are restricted to high salinity waters.

Blue crabs, *Callinectes sapidus*, use different salinity regimes at different times in their life history. The females spawn near or in the Gulf and the planktonic larvae settle to the bottom. Post-larval stages move upstream with the saline deep water into the estuary. Mating occurs in low and middle salinity water, and the females return to the Gulf to spawn.

Drum and menhaden spawn at the entrance to estuaries and the young are transported by the deep salty water upstream in the estuary to plankton rich low salinity areas. Here the juvenile drum and menhaden feed and as they mature move out to saltier water again.

Mullet (*Mugil cephalus*) are a multimillion dollar fishery in Florida, \$3.5 million worth was landed in 1974 (29 million pounds). Mullet are believed to spawn in the Gulf between October and December (Springer & Woodburn, 1960). The young move quickly into protected lower salinity waters, where they feed on small zooplankton until they reach about 25mm in length (W.E. Odum, 1970). In April in Tampa Bay, greater numbers of young appear, apparently coming out into the bay from creeks and bayous (Springer & Woodburn, 1960). As they grow larger than 25mm, mullet become strict detritus - algal feeders, ingesting benthic diatoms, filamentous algae, vascular plant detritus and inorganic sediment particles (W.E. Odum, 1971).

In contrast to mullet, bay anchovies, *Anchoa mitchilli*, are plankton feeders throughout their lives. Larval and juvenile forms feed on microzooplankton which in turn, depend on phytoplankton production for food. Larger anchovies eat a variety of herbivores which derive their nutrients from both planktonic production and detritus (W.E. Odum, 1971). Anchovies were the most abundant fish found in Charlotte Harbor by Wang & Raney (1971), and have greater biomass than any other estuarine fish species in the Gulf States (Gunter, Gordon, 1967).

The gamefish tarpon, *Megalops atlanticus*, snook, *Centropomus undecimalis*, ladyfish, *Elops saurus*, grey snapper, *Lutjanus griseus*, sheepshead, *Archosargus probactocephalus*, spotted seatrout, *cynoscian nebulosus*, and red drum, *sciaenops ocellata*, utilize mangrove habitat for large periods of time during their life history. All of these game fish feed on detritus feeders (W.E. Odum, 1971).

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TAMPA BAY

The name "Tampa Bay" is used to identify two geographic areas - the Tampa Bay estuarine region and Tampa Bay proper. The Tampa Bay estuarine region consists of a number of smaller areas including Old Tampa Bay, Hillsborough Bay, Tampa Bay proper, Boca Ciega Bay, and the area around the mouth of the Manatee River.

McNulty et al. (1972) includes the mouth of the Manatee River in Tampa Bay proper. Tampa Bay proper receives fresh water from the Manatee and Little Manatee Rivers. We have grouped Tampa Bay proper together with Hillsborough Bay as being the estuarine area that may be directly affected by commercial phosphate operations. The Hillsborough and Alafia Rivers flow into Hillsborough Bay.

Simon (1974) reports that Tampa Bay is 5 times larger than Hillsborough Bay, their total surface area being 240 sq miles of the entire system's 340 sq. miles. The mean depth of the entire system is 11 feet. The Hillsborough/Tampa study area has a shoreline of 133.7 miles and a volume at mean high water of 2,674,490 acre-ft.

The Tampa Bay estuarine region has been subjected to a wide range of technological insults, including: navigational dredging (42 plus miles), discharge of human sewage effluent, more than 37 miles of bridges and causeways, dredge and fill development of the bayfront and bay bottom, and industrial pollution (Simon, 1974). The vast majority of these estuarine stresses can be traced to the people -- one sixth of Florida's population (Simon, 1974) -- that live in the Tampa Bay area. Hillsborough Bay is rated as Class V water - suitable only for non-contact recreation and navigation (McNulty et al., 1972). The number of mollusc species in Hillsborough Bay is reported to have dropped from over 20 to less than 4 (McNulty et al., 1972).

TAMPA BAY SALINITY

Generally, water circulates counterclockwise in Tampa Bay, with the flood tide concentrating along the eastern shore, and out flowing water concentrated along the western shore. Hillsborough Bay exhibits little circulation, effectively trapping the industrial and municipal effluents that outfall into it (Simon, 1974). Hillsborough Bay received an average of 35.642 million gallons per day of sewage effluent in 1974. Fig. 5, a mathematical model of velocities in Tampa Bay, illustrates the trapping internal circulation of Hillsborough Bay.

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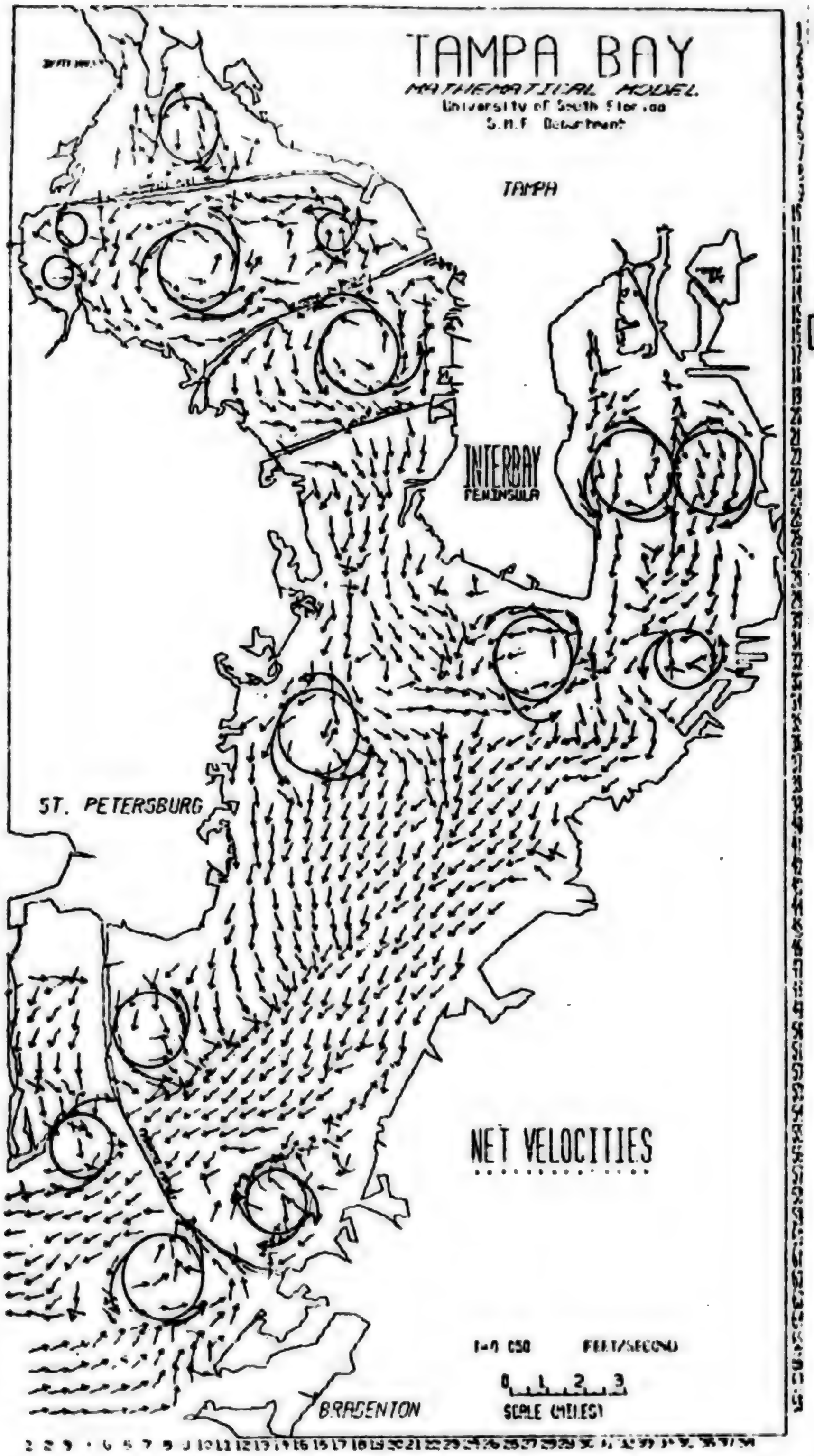

Figure 5. -- Net velocities at each point for one tidal cycle. From Ross, B.E., 1973.

Figure 6 shows mean salinity and salinity range for Tampa Bay stations, according to McNulty et al. (1972). Simon (1974) reports the average annual salinity for the entire system is 29.5 p.p.t. Simon (1974) also relates that Finucane and Dragovich found a verticle salinity gradient of 1.4 p.p.t. at the surface and 20.5 p.p.t. at the bottom somewhere in Tampa Bay, evidence of a salty deep water wedge under a fresh water surface wedge. Wide fluctuations in the salinity regime are generally absent in the Tampa Bay area allowing marine and estuarine species to coexist in the bay (Simon, 1974).

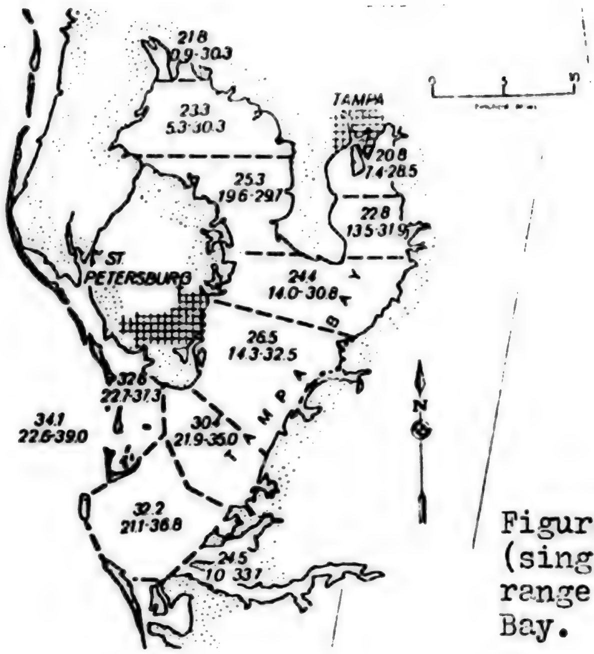

Figure 6. -- Mean salinity, (single figure) and salinity range (two figures) in Tampa Bay. From McNulty etal., 1972.

TAMPA BAY DISSOLVED NUTRIENTS

The comparative table, taken from Simon (1974) shows the dissolved N and P concentrations for waters of Hillsborough Bay and Upper and Lower Tampa Bay. (Table 1). In Hillsborough Bay, high levels of N are attributed to sewage effluents, while high P concentrations are contributed by the Alafia River. Major quantities of N and P accumulate in Hillsborough Bay, resulting in N and P values 10 times values normal for offshore waters. (Simon, 1974).

	1962		1972	
	N	P	N	P
Hillsborough Bay	56.6	25.9	37.7	71.0
Tampa Bay Upper	37.2	23.4	23.6	38.7
Tampa Bay Lower	32.0	8.6	14.3	11.9

Table 1. Total Kjeldahl nitrogen (N) and total phosphorous (P) ga./l for the Tampa Bay system.

MANGROVES OF TAMPA BAY

McNulty et al. (1972) estimated that there were 10,026 acres of mangroves extant in the Tampa/Hillsborough system. Tampa Bay proper accounted for 88 percent of this total. Hillsborough Bay is particularly mangrove deficient - there being only 31 acres of mangrove for each running mile of shoreline. Tampa Bay proper averages 90 acres mangrove per mile of shoreline, and the Charlotte Harbor estuarine region averages 225 acres of mangrove per mile of shoreline.

In the last five years, the mangroves of the Tampa/Hillsborough area have become the focus of a number of studies investigating natural and subsidized mangrove sucession on disturbed sites (Detweiler et al., 1975, Lewis and Dunstan, 1975). Additional research at the Cockroach Bay Station promises to document the role of relatively undisturbed mangroves as they approach the northern limits of their range.

TIDAL MARSHES OF TAMPA BAY

McNulty et al. (1972) found 203 acres of Tidal Marsh in Hillsborough Bay and 843 acres of Tidal Marsh in Tampa Bay proper. They apparently could not use the 4222 acres of drained tidal marsh they found in these two bays in their computations of existing tidal marsh. Seventy-eight percent of Tampa Bay proper's marsh has been drained and 86 percent of Hillsborough Bay's marshes have been drained.

TAMPA BAY SEAGRASSES

Five species of seagrass, and 216 species of benthic algae are found in Tampa Bay seagrass beds. In Tampa Bay proper, 7,890 acres are vegetated by seagrass beds, compared with 383 acres in Hillsborough Bay (McNulty et al., 1972).

A study of seagrass distribution in Tampa Bay (Phillips, 1960) indicated that growth is limited to that area shoreward of the six foot depth contour, probably due to high water turbidity. Restricted to shallow areas, seagrass beds are further encroached by filling. *Ruppia maritima*, wideg on grass, and *Diplanthera wrightii*, shoal grass, are characteristically dominant from MLW to the spring low tide line. *Syringodium filiforme* dominates over *Thalassia testudium*, turtle grass, which is uncommon in Tampa Bay, probably due to turbidity. Degradation of water quality in Hillsborough Bay has caused many macroalgae species to be reduced or eliminated, allowing obnoxious species such as *Gracilaria*, *Enteromorpha*, and *Ulva* to be present in extraordinary quantities. (Simon, 1974).

TAMPA BAY PLANKTON

Phytoplankton gross annual productivity is estimated to be between 314 and 427 gm per m^2, by Steidinger according to Simon (1974). This is a high or higher than any other area in the world. Productivity is highest in the spring and late summer, and is always higher in Hillsborough Bay than other bays within the system (Simon, 1974).

Hillsborough Bay, as stated earlier, receives great quantities of dissolved nutrients in the form of sewage effluents, as well as the nutrient loads of the Hillsborough, Palm, and Alafia Rivers. These have, in the past, stimulated tremendous growth of the benthic algae Gracilaria. High levels of nutrients trapped and dissolved in Hillsborough Bay are also accountable for phytoplankton productivity higher than elsewhere in the world. High levels of dissolved nutrients often stimulate the growth of "weed" plankton species. Speaking of a similar situation in Moriches Bay, Ketchum and Bostwick (1967) state, "the weed species which grow so prolifically in this estuary are not themselves good food for many of the normal populations, such as the oyster, but their growth excludes the normal estuarine phytoplankton species. While fertilization may increase the production of species of value to mankind, uncontrolled pollution, even though it may increase the total productivity of phytoplankton, may destroy the natural resources of an estuary."

As Ketchum and Bostwick have predicted, even though Hillsborough Bay has quite high phytoplankton productivity, its invertebrate assemblages are highly degraded, and smaller catches of fewer species of fish take place there than in other areas of the Tampa Bay system (Simon, 1974).

Zooplankton have not been well studied in Tampa Bay. Generally, zooplankton increases in diversity as salinity increases in Tampa Bay. Ctenophores are known to graze heavily on microzooplankton in the winter. Fish eggs are most abundant between February and May, and larval fishes show greatest numbers in July (Simon, 1974).

TAMPA BAY FISHERIES

Finucane and Sykes (1964) found 21 species of fish commercially important in Gulf fisheries to occupy Tampa Bay while inmature. (Table 2). They stressed the importance of Tampa Bay as a nursery area for fish, crustaceans, and molluscs of commercial importance in the Gulf. They also found that even though low salinities would favor a great abundance of juveniles of important species in Hillsborough Bay, fisheries in that area were on the decline. They attributed the decline to industrial and domestic sewage accumulating in the area, resulting in unstable and uninhabitable sediments, and destruction of marine grass beds in littoral areas.

- *Mugil curema*
  - silver mullet
- *Mugil trichodon*
  - silver mullet
- *Scomberomorus maculatus*
  - spanish mackerel
- *Trachinotus carolinus*
  - pompano
- *Mugil cephalus*
  - striped mullet
- *Mycteroperca microlepis*
  - gag
- *Epinephelus morio*
  - red grouper
- *Caranx hippos*
  - crevalle jack
- *Trachinotus* sp.
  - permit
- *Leiostomus xanthurus*
  - spot
- *Cynoscion nebulosus*
  - spotted seatrout
- *Eucinostomus gula*
  - mojarra
- *Eucinostomus argenteus*
  - mojarra
- *Diapterus plumieri*
  - mojarra
- *Callinectes sapidus*
  - blue crab
- *Sciaenops ocellata*
  - red drum
- *Cynoscion arenarius*
  - white seatrout
- *Archosargus probatocephalus*
  - sheepshead
- *Penaeus duorarum*
  - pink shrimp
- *Pogonias cromis*
  - black drum
- *Brevortia patronus*
  - menhaden
- *Brevortia smithi*
  - menhaden

Table 2. -- Commercial fish and shellfish of Tampa Bay. From Sykes and Finucane, 1964.

Springer and Woodburn's (1960) ecological study of fishes characterizes the fish fauna of several habitats in Tampa Bay. Typical shallow bay habitat has relatively high and stable salinities, and heavy bottom vegetation. Proceeding upstream from the Gulf the number of species of fish decreases, but not the total biomass. Fish also decrease in numbers as the bottom vegetation dies back in winter.

Bayous, particularly cutbacks and flats leading off the main channel, are the most densely populated fish habitat found in the bay system. The fish are young and small. The bayou undergoes wide salinity fluctuations. Engraulids, young mugilids, atherinids, gerrids, sciaenids, and ariids, are most common. Dense population of young menhaden inhabited the bayous at certain times of the year.

Murdock (1957) reported on the commercial and sport fisheries of the Manatee River in Lower Tampa Bay. He found that 30 species used the Manatee River for either spawning or nursery ground. Notably he found Redfish, striped mullet, snook, and black drum to spawn in the Gulf or passes, and the larval and young fish use the Manatee River as nursery grounds. Spotted seatrout spawn over inshore grass flats. Of course, current fish use of the Manatee River could be quite different.

Commercial fish landings, according to Simon (1974), are summarized in Table 3 .

Table 3

Commercial Fishlandings in the Tampa Bay Region, 1970

	Thousands of Pounds
Blue Runner	45
Grouper	3,701
King Mackerel	213
Striped Mullet	5,875
Pompano	47
Spotted Sea Trout	344
Red Snapper	676
Spanish Mackerel	235

TAMPA BAY AVIFAUNA

McNulty et al. (1972) reports that pelican eggshells in nearby Pinellas County were thinner than other Gulf Coast Florida pelican eggshells. Woolfenden and Schreiber (1973) report that Conners et al. found nine heavy metals (Ag, Cd, Co, Cr, Cu, Hg, Ni, Pb, and Zn) in Tampa Bay pelicans, the mercury being particularly high. Woolfenden and Schreiber go on to suggest that any factor decreasing the availability of fish eaten by pelicans would have drastic effects on the population. In light of Sykes and Finucane's (1964) conclusion that Hillsborough Bay is no longer a productive nursery area, one could conclude that the avifauna of the Tampa/Hillsborough system are severely stressed.

Birds continue to use the area, many paradoxically roosting and nesting on an old spoil island in the mouth of the Alafia River - a historic contributor of acid, turbid, phosphate and fluoride-laden water to Hillsborough Bay (Florida State Board of Health, 1955). Roy R. Lewis (personal communication) reports that the birds using this island tend to feed elsewhere.

CHARLOTTE HARBOR

The name "Charlotte Harbor" serves to identify two geographic areas -- the Charlotte Harbor estuarine region, and Charlotte Harbor proper.

The Charlotte Harbor estuarine region is a large complex estuarine system that includes the mouths of the Peace, Myakka, and Caloosahatchee Rivers, San Carlos Bay, Pine Island Sound, Gasparilla Sound, Charlotte Harbor, Matalacha Pass, the islands and wetlands adjacent to these areas, and, in some views, portions of Estero and Lemon Bays.

Charlotte Harbor proper originates in the mouths of the Peace and Myakka Rivers and extends to Boca Grande Pass, excluding Pine Island Sound and Matlacha Pass. Some researchers (McNulty et al., 1972) include Gasparilla Sound, Turtle Bay, and Bull Bay with Charlotte Harbor, but this is not a universal practice. We have decided to include Gasparilla Sound, etc. with Charlotte Harbor in an attempt to compensate for the effects Charlotte Harbor must have on Pine Island Sound, which we are excluding from our consideration of the effects of phosphate operations.

Taylor (1974) reports that the Charlotte Harbor estuarine region covers a water area of at least 280 square miles at an average depth of 10 to 12 feet. This represents a calculated volume at mean high water of close to 2.4 million acre-ft. The region as a whole has more than 200 miles of shoreline.

In relation to Tampa Bay, Charlotte Harbor may be seen to be about 18 percent smaller in water area and hold about a million less acre-ft. at mean high water, but Charlotte Harbor has a lower ratio of water area/shoreline than Tampa Bay (1.4 vs. 1.7)* and almost three times more acres of seagrass, tidal marsh and mangroves than Tampa Bay"(McNulty et al., 1972).

According to a report prepared by the Florida Department of Natural Resources: "If there is a mirror image of the Charlotte Harbor estuarine system, it is Tampa Bay. The primary difference is that Charlotte Harbor is an example of what Tampa Bay was like in.... 1920"(Sarasota Herald-Tribune, 1977).

Under the State's Environmentally Endangered Lands Program, $5.4 million has been spent to acquire land on Cayo Costa, a remarkably well preserved barrier island just south of Boca Grande. The state is now actively negotiating purchase of more than 20,000 acres of wetlands surrounding Charlotte Harbor (Sarasota Herald-Tribune, 1977).

* Figures from Simon, 1974 exclude Boca Ciega Bay.

According to H. K. Brooks (1973), Charlotte Harbor is the most scenic estuary in the area of the eastern Gulf of Mexico. Taylor (1974) reports that Wang and Raney found Charlotte Harbor to be perhaps the least contaminated of the estuarine complexes in the State of Florida. Figure 7 taken from McNulty et al., (1972), suggests the relative amounts of pollutants entering the Charlotte Harbor to Marco area as compared with the Englewood to Pinellas County area.

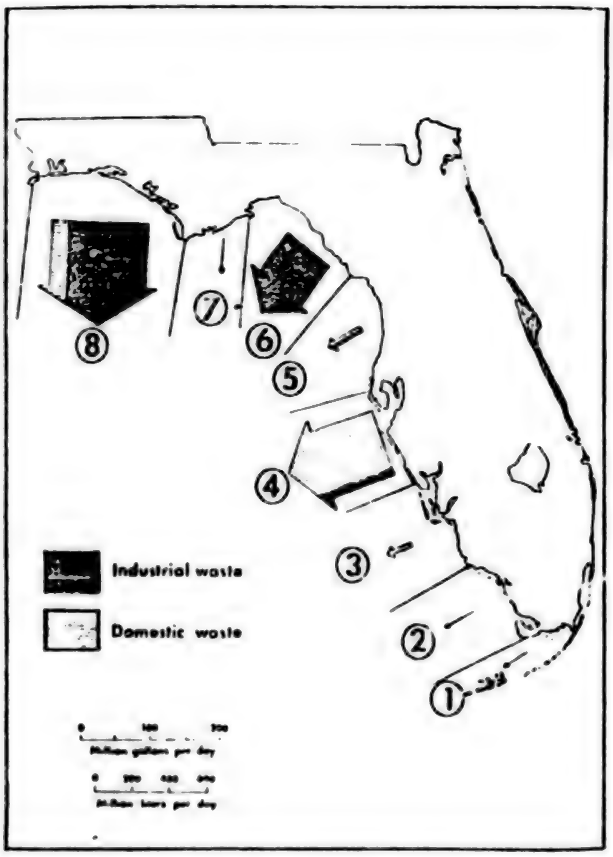

Figure 7—The flow of pollutants into estuarine areas by coastal segment. Circled numbers are coastal segment numbers.

The State of Florida is currently considering Charlotte Harbor as an Area of Critical State Concern. State concern stems from the realization that Charlotte Harbor's integrity as an estuary, is threatened by extensive platted and planned developments encircling the system and alterations of water quantity and quality of its contributing rivers and creeks.

CHARLOTTE HARBOR SALINITY

According to Alberts et al., (1970) "On a flood tide the east end of the estuary becomes vertically mixed and there is a gradual transition to a well defined salinity wedge at the mouth of the Peace River. The discharge of the Peace River is well defined by the tongue of low salinity water which follows the east and north sides of the estuary." Figure 8 shows mean salinities and range of salinities in parts per thousand for stations in Charlotte Harbor.

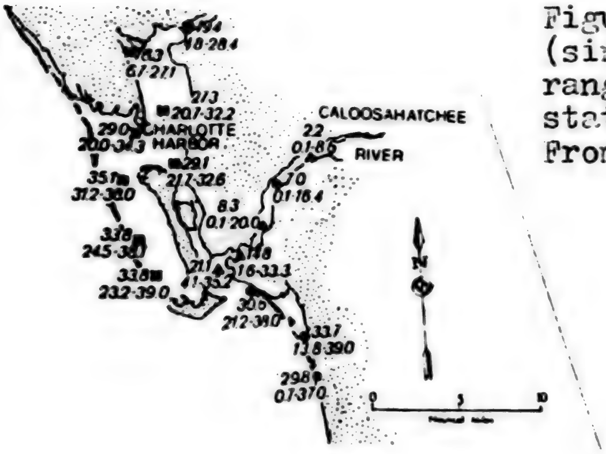

Figure 8. -- Mean salinity (single figure) and salinity range (two figures) for stations in Charlotte Harbor. From McNulty et al., 1972.

Wang and Raney (1971) found fresh water as far into the estuary as Cape Haze after much rain in June of 1968. In December, 1968, fresh water had retreated to Liverpool Island, several miles upstream from Punta Gorda on the Peace River.

CHARLOTTE HARBOR SEDIMENTS

Taylor (1974) states on the basis of Huang (1966) that the sediments of Charlotte Harbor originate as upland soils that are delivered to the harbor via land drainage or are a mixture of quartz sand and shell fragments brought into the harbor by tidal currents, or are the calcareous remains of marine organisms . Sediments deposited in the last 100 years average 10 feet in thickness and are located in the harbour head and central areas of the sounds (Huang, Goodell, 1967). Percent organic carbon and percent organic nitrogen in the sediments increases from Boca Grande towards the mouths of the Peace and Myakka Rivers. Percent phosphate in Charlotte Harbor sediments is shown in Figure 9 .

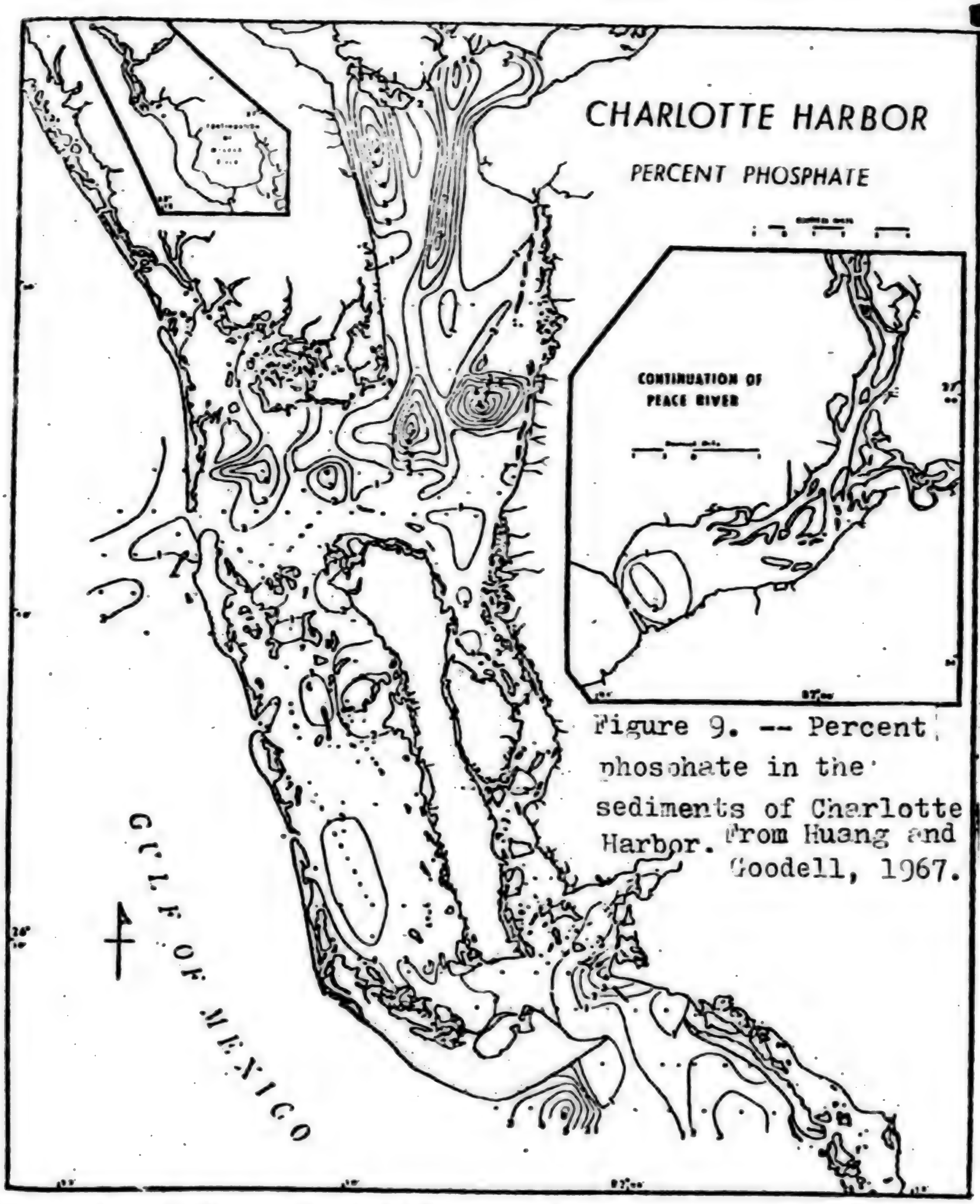

Figure 9. -- Percent phosphate in the sediments of Charlotte Harbor. From Huang and Goodell, 1967.

CHARLOTTE HARBOR DISSOLVED NUTRIENTS

Taylor (1974) states that the Myakka and Peace Rivers, compared to other rivers, oceans, and estuaries, are rich in terms of substances of importance to biological production, and that present productivity is limited by low levels of nitrogen compared to phosphorous. Table 4 shows PO4, N, Chlorophyll a and primary productivity for these two rivers.

	Myakka River		Peace River	
Factor	Mean	Range	Mean	Range
I-PO, -P, ug at/1	3.9	0.3-6.9	16.7	0.0-26.6
T-PO, -P, ug at/1	6.4	2.0-12.4	19.4	0.9-33.7
Nitrite-N, ppm	0.009	0.0-0.008	0.10	0.0-0.005
Nitrate-N, ppm	2.11	0.2-6.0	1.78	0.1-4.5
T-organic-N, ug at/1	21.94	8.68-56.70	16.91	5.01-50.40
Chlorophyll a, mg/m'	5.25		8.74	
Primary Prod., gC/m^2/dav	0.87	0.46-1.58	1.44	0.56-2.91

Table 4. -- Dissolved nutrients of Charlotte Harbor tributaries. From Taylor, 1974.

MANGROVES OF CHARLOTTE HARBOR

McNulty et al. (1972) calculated that the entire Charlotte Harbor region contained 45,104 acres of mangroves, Charlotte Harbor proper having slightly more than half - 23,474 acres. Taylor (1974), using data from Odum, Heald, and Teal, concluded that primary production in mangroves amounts to about 8,000 lbs. per acre per year. No estimate was made regarding what percent of this entered the estuarine detritus cycle. Using Taylor's figures, we determined that Charlotte Harbor proper's mangroves produce close to 94,000 tons of dry organic matter each year.

TIDAL MARSHES OF CHARLOTTE HARBOR

Taylor (1974) states that the salt marsh community of Charlotte Harbor consists of the following species: *Spartina alterniflora*, *Juncus roemerianus*, and *Spartina patens*.

McNulty et al. (1972) calculated that the entire Charlotte Harbor region contained 18,261 acres of tidal marsh, Charlotte Harbor proper having slightly less than half - 9,087 acres. Taylor (1974), using data from Odum, Heald, and Teal, concluded that primary production in salt marsh amounts to about 20,000 lbs. per acre per year. McNulty et al. (1972) uses the same figures. Because Heald (1971) felt that 4/5 of this rate would represent much greater productivity than he found in the *Juncus* marshes of the North River, we suspect that the much smaller tidal marshes are not generating the same total amount of dry organic material each year as the mangroves of Charlotte Harbor proper. Nevertheless, Heald's (1971) standing crop of dead *Juncus* material of 84.9 g/1/10m^2 is quite comparable to his 876 g/m^2 for mangroves reported in McNulty et al. (1972). The tidal marshes of Charlotte Harbor may well be just as productive as the mangroves on a unit per unit basis.

CHARLOTTE HARBOR SEAGRASSES

Charlotte Harbor proper contains 23,383 acres of seagrass beds, or approximately 1/5 of its total area is vegetated by seagrass associations (McNulty et al., 1972). The association includes five species of seagrass, *Thalassia testudium*, *Diplanthera wrightii*, *Ruppia maritima*, *Halophila engelmanmi*, *Syringodium filiforme*, and more than 200 species of algae. Seagrass and attached algae in the entire Charlotte Harbor estuarine complex are thought to produce 0.5 million tons of dry organic matter annually (Taylor, 1974). Dredging and filling have damaged many grass beds in the vicinity of Port Charlotte and Punta Gorda in the last 10 years.

CHARLOTTE HARBOR PLANKTON

Taylor (1974) cites May and Steidinger as calculating net primary productivity by microalgae in the Charlotte Harbor estuarine region amounting to 25g of dry organic matter/m^2/year. He states that "this figure compares favorably with estimates from highly productive fresh and marine waters throughout the world."

Phytoplankton are most abundant in Charlotte Harbor during September and October, and, because they feed largely on phytoplankton, zooplankton populations also peak in September and October. Copepods are the most abundant zooplankters found in Charlotte Harbor.

CHARLOTTE HARBOR FISHERIES

The following discussion of fish and fisheries in Charlotte Harbor is excerpted from Taylor (1974):

> ". . . perhaps most important ichthyological investigation, was done by Wang and Raney (1971). They surveyed the entire estuary and recorded 125 fishes. In addition, they reviewed all previous reports, as well as collections in the Mote Marine Laboratory, and compiled a composite list of fishes for the estuary that contained 246 species. These authors also concluded that the bay anchovy and pinfish are the most common fishes in the complex, and in order of lesser abundance, they ranked the following additional species: silver perch (Bairdiella chrysura), pigfish (Orthopristis chrysopterus), silver jenny (Eucinostomus gula), and sand seatrout (Cynoscion arenarius). From a comparison of collections at all stations, they also found that the largest resident and migratory fish populations occur in Gasparilla Sound, Placida Harbor, and northern Pine Island Sound. However, even in those areas they found a decline in numbers and kinds of fishes during periods of high river flow (reduced salinity), and in winter when water temperature was low.
>
> McNulty, Lindall, and Anthony took fishes by seine and trawl over a 12 month period at the northern end of Pine Island near Bookelia in their recent study. The pinfish was the dominant species in their samples, and they found that the time of greatest overall fish abundance was the 6 month period from April through September.
>
> Many of the species reported in studies referred to above are harvested in sport and commercial fisheries of the estuary. The most highly prized sport fishes include tarpon (Megalops atlantica), snook (Centropomis undecimalis), sheepshead (Archosargus probatocephalus), spotted seatrout (Cynoscion nebulosus), gray snapper (Lutjanus griseus), and red drum (Sciaenops ocellata).

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Among the commercially important species there are at least 18 that have an annual dockside value in excess of $1,000 (Heald, 1970), and in terms of poundage, the most important species include mullet, spotted seatrout, groupers, king and spanish mackerels, red drum, mojarra, pompano, and jacks (Florida Department of Natural Resources, 1973). For the entire estuary, the annual harvest of finfish amounts to about 15.9 million lb, and has a dockside value of approximately $3,000,000. Based on rough estimates, the catch of sportfishes amounts to between one-third and one-half of the poundage reported for commercial species, but money spent by sportfishermen probably equals or exceeds the annual wholesale value of commercial fishes (Taylor et al., 1973). Obviously, this level of natural production represents an extremely important natural resource. However, as Lindall (1973) pointed out, regional fisheries for both sport and commercial species may be seriously degraded by estuarine modifications in the form of drainage projects, domestic and industrial pollution, pesticide contamination, thermal additions, and dredging and filling."

CHARLOTTE HARBOR: AVIFAUNA

The list of aquatic birds of salt water habitat that follows is from a preliminary report to the Conservation Foundation regarding Sanibel Island, compiled by Oliver Hewitt in 1975. To this list we would add, from personal observation, white pelican, magnificent frigatebird, fish crow, and reddish egret, to obtain a representative bird list for Charlotte Harbor.

TABLE 5
From O.H. Hewitt, 1975
Aquatic Birds of Predominantly Salt Water Habitat

Brown Pelican	Pelicanus occidentalis
Double-crested Cormorant	Phalacrocorax auritus
Great Blue Heron	Ardea herodias
Green Heron	Butorides virescens
Snowy Egret	Leucophoyx thula
Louisiana Heron	Hydranassa tricolor
Little Blue Heron	Florida caerulea
Black-crowned Night Heron	Nycticorax nycticorax
Yellow-crowned Night Heron	Nycticorax violacea
White Ibis	Eudocimus albus
Roseate Spoonbill	Ajaia ajaia
Lesser Scaup Duck	Aythya affinis
Red Breasted Merganser	Mergus serrator
Bald eagle	Haliaeetus leucocephalus
Osprey	Pandion haliaetus

Clapper Rail	*Rallus longirostrus*
American Oystercatcher	*Haematopus palliatus*
Piping Plover	*Charadrius melodius*
Snowy Plover	*Charadrius nivosus*
Wilson's Plover	*Charadrius wilsoni*
Black-bellied Plover	*Squatarola squatarola*
Ruddy Turnstone	*Arenaria interpres*
Eastern Willet	*Catoptrophorus semipalmatus*
Laughing Gull	*Larus atricilla*
Least Tern	*Sterna albifrons*
Black Skimmer	*Rhynchops nigra*

Cormorants, Ibis, Herons, Egrets, Eagles, Ospreys, Brown Pelicans, and Fish crows all utilize mangroves as nesting sites. Shorebirds, gulls, terns, and skimmers rely on sandy bars, shoals, flats and beaches for nesting and resting. Bird species represented in Charlotte Harbor derive food from herbivores, (zooplankton) Omnivores (killifish and shrimp) primary carnivores, and middle carnivores (crabs, anchovies, silver jenny, etc.).

[redacted]

II. IMPACTS

PHOSPHATES IN LOCAL RIVERS

The Peace River, draining the largest watershed in the study area, has the longest history with phosphate. Nearly 100 years ago, Captain J.F. LeBaron of the Engineer Corps of the U.S. Army discovered rich phosphate deposits in the river bed of the Peace River. Mining in the river began in earnest 90 years ago. For 21 years phosphate was mined from the bottom and sides of the Peace River with floating dredges that discharged the spoil back into the river. One can only speculate about the effect this operation had upon the biota of the river and Charlotte Harbor.

Although it may be possible through analysis of sediments to ascertain the pre-discovery levels of phosphate contribution to Charlotte Harbor via the Peace River, it is virtually impossible to determine how well adapted the biota of the estuary was to these levels of phosphate.

From the bust of 1908 until the present, phosphate mining operations in the Peace River watershed have risen and fallen with wars, depressions, and booms. One would expect that the changes in technique and levels of production that have taken place over the years have complicated the situation of organisms attempting to utilize or tolerate dissolved phosphate.

Concern about phosphate mining in the watershed apparently started about a third of a century ago. According to Lanquist (1953) it was during and after World War II that "the phrase, 'Fishing isn't as good as it used to be,' began to be used." The citizens were upset about silt and slimes killing fish. Since that time a number of slime spills have occured in the watershed.

Like the other historical phosphate river, the Peace, the Alafia River basin has been worked and reworked for phosphate since the late 1800's. Because most of the phosphate processing facilities are located in the headwater areas of the Alafia River Basin (Toler, 1967) the quality of the river water and its receiving estuary has generally been lower than that of the Peace River. Like the Peace, slime spills and turbid water releases are an integral part of this river's history (Florida State Board of Health, 1955). Some of the effects of phosphate processing in the Alafia watershed are discussed elsewhere in this report.

The remaining rivers vary in their phosphate contributions. The Hillsborough is high due to sewage and the Manatee and Myakka Rivers are consistently low (Table 6). Table 7 summarizes Odum's (1953) findings for phosphorus in Florida streams.

ppm total phosphorus

	Phosphate District	Other Areas
streams	.876 (18)	.046 (44)
estuaries	.269 (2)	.044 (21)

Figures in parentheses indicates the number of water bodies used in computing the average.

Table 7 -- Mean Values of Phosphorus in Florida Waters from Odum, 1953.

ALAFIA R.	PEACE R.	LITTLE MANATEE R.	HILLSBOROUGH R.	MANATEE R.	MYAKKA R.	
.660	.423	.610	.220	.097	.069	Dissolved Phosphorus ppm River Mouths Odum, 1952
39.2	----	14.9	10.3	11.8	----	Mean Total PO_4 Phosphate Oct. 1958 - Dec. 1959 Bottom Samples River Mouths Dragovich and May, 1962
29.1	18.4	24.8	19.1	16.6	7.2	Mean Total PO_4 Phosphate Jan. 1964- Jan. 1965 Bottom Samples River Mouths Dragovich et al., 1968
120	344	24.4	244	15.7	54.2	Total Phosphorus Metric Tons Jan. 1964 - Jan. 1965 Dragovich et al., 1968
2.63	1.44* 7.39	.71	1.92	.69	.87	Mean Estimates of Primary Productivity ($g. C/m.^2/day$) Dragovich et al., 1968

Table 6. -- Phosphate in S.W. Fla. Rivers.
*top figure is Punta Gorda, bottom is Arcadia

DISSOLVED AND SEDIMENTED PHOSPHORUS

As discussed in the preceeding section, local Florida waters have naturally occuring high levels of phosphorus. These naturally high levels are added to by phosphate discharges from mining operations. Hobbie (1974) quotes Gallagher and Hagan (Southeast Water Lab) as having determined that phosphate mining wastes are the major source of phosphorus for Hillsborough Bay. Between the years 1962 and 1972 levels of dissolved phosphorus in Hillsborough Bay have nearly tripled (Simon, 1974).

Odum (1953) notes that the unusually high phosphorus values reported for Tampa Bay and Charlotte Harbor could be further increased by acid industrial pollutants, since the solubility of phosphorus increases with decreasing pH. Most phosphate mines and phosphate processing facilities have some discharge of acid waste water. Higher levels of dissolved phosphate allow high phosphate concentrations to be introduced into organic fractions and into colloidal and soluble forms.

Phosphates contained in estuarine sediments are readily exchanged with overlying waters by two methods. Ions can be exchanged between clay minerals and the water, or, paticularly when sediments are stirred up and suspended, biological exchange occurs, nearly equaling the clay ion exchange in amount of phosphorus moved. Rates of phosphorus exchange between sediments and water are adequate enough to maintain dissolved phosphorus at levels favorable to plant production, even though phytoplankton blooms and tidal flow are constantly decreasing concentrations of phosphorus in the water (Pomeroy et al., 1965)(Duke and Rice, 1966).

The atomic ratio of available N:P in seawater is 15:1. Though the ratio of N:P in phytoplankton is commonly 15:1 as well, Ryther and Dunstan (1971) have concluded that 10:1 is a better working value. This means that phytoplankton require ten times as much nitrogen as phosphorus as nutrients for their growth. In many areas dissolved nitrogen is more than ten times as abundant as dissolved phosphorus, and phytoplankton blooms either don't occur or are of short duration, the limiting nutrient being phosphorus. In other areas, particularly estuaries receiving domestic sewage effluents, nitrogen is the limiting nutrient. In Moriches Bay Ryther and Dunstan (1971) found N to be limiting in phytoplankton blooms stimulated by wastes from a duck farm. Dissolved forms of nitrogen were completely depleted in the area of the blooms, while excess phosphorus was evident dissolved in the water. The atomic nitrogen to phosphorus ratic in primarily treated sewage is 5.8:1; in secondarily treated sewage it is 5.4:1 (Ryther and Dunstan, 1971). If these dissolved nutrients are used directly by phytoplankton in a typical 10:1 ratio, half of the phosphorus would still be left when all the nitrogen was used up.

Tampa Bay and Charlotte Harbor both appear to be nitrogen limited, though in very different ways. Hillsborough Bay receives both primarily and secondarily treated domestic sewage, acid waters, and phosphate mining wastes delivered by the Alafia river. Further, water circulation traps great quantities of these nurrients in the sediments of Hillsborough Bay. All of these inputs have resulted in "high BOD's, low DO's, unsafe levels of fecal coliforms, high primary productivity, organically rich anaerobic sediments, frequent fish kills and obnoxious algal blooms" (Simon, 1974)). Hobbie (1974) suggests that the N:P ratio in Hillsborough Bay is close to 1:3, phosphorus levels being 100 times higher than normal estuarine concentrations. This phosphorus will only be used by phytoplankton in the Bay to the extent that 10 times as much nitrogen is available. The primary input of nitrogen into the Bay is from domestic sewage, but this effluent itself contains phosphorus in an N:P ratio of about 5:1. Nitrogen is clearly the limiting nutrient for primary productivity by phytoplankton in Tampa Bay.

Alberts et al. (1970) detected a wedge of high phosphorus Peace River water extending all the way to Boca Grande Pass. They found surface water concentrations of phosphorus in Charlotte Harbor ranging from .572 ppm - .188 ppm, while preliminary studies of dissolved nitrate showed a range of values for Charlotte Harbor of .05-0.1 ppm. Once again phytoplankton productivity is probably limited by low levels of nitrogen in relation to phosphorus. Addition of sewage effluents from the rapidly growing residential areas surrounding the Harbor may stimulate greater productivity, but the effluent itself would be limited by nitrogen, and the stored phosphorus in the Harbor would not come into play.

Only if a pollutant containing more than 10 times as much nitrogen as phosphorus is discharged into the Harbor, or if nitrogen fixing bluegreen algaes become prevalent, will the excessive amounts of phosphorus dissolved and stored in the sediments of Charlotte Harbor be utilized for primary productivity.

None of the literature suggests any deleterious effects of excessive phosphorus in estuaries, beyond those already discussed of stimulation of excessive phytoplankton productivity when in combination with adequate nitrogen.

REDUCTIONS IN FRESHWATER FLOW

Pollution of rivers and estuaries by dissolved phosphate, slimes, fluorite, acid wastes, and other substances represents a change in the quality of surface water. Two other attributes of surface water flow, quantity and timing, also bear on the ecological functioning of estuaries.

The amount of water flowing in a river is a complex function of meteorological, geological, biological, and cultural events. Estuarine species must cope with wide variations in river quality, quantity, and timing. The highly dynamic nature of estuaries suggests that organisms that reside there are frequently stressed. Could additional or amplified changes in stream flow characteristics overstress the organisms we generally conceive of as adaptable?

A recent seminar, Freshwater and the Florida Coast, sought to address this question: ". . .how much water can be removed 'upstream' and yet still provide sufficient flow to support estuarine systems"? This is primarily a question of quantity - how much freshwater is needed in the estuaries?

In a document related to SWFWMD's seminar, Snedaker et al. (1977) enumerated changes that have been known to accompany reductions of freshwater flow. These include an increase of nearshore salinity, sometimes becoming hypersaline; a minimization of mixing that accompany salinity differentials; the salt-wedge may move upstream; salt water intrusion may occur; terrestrial nutrient flows are reduced; benthic substrate can tend towards anerobic conditions, heavy metals in substrate can become liberated, and sulfur cycles can gain in dominance. In addition, organic matter inputs are reduced and/or deposited more, sometimes resulting in a loss of "organic roadmaps" that enable migratory species such as shrimp, mullet, black drum, redfish, sea trout, menhaden, bluefish, king and spanish mackerals to find their way into estauries. Species composition of the estuary can change as a result of reduced freshwater flow: salt-tolerant mosquitoes can increase, stenohaline species can replace euryhaline species, and elevated salinities can stress estuarine plant communities. Other changes include reductions of silt and sand loads reaching the estuary and alterations of littoral drift and nearshore circulation patterns. All of these impacts are aggravated by the seasonal low flow conditions experienced in southwest Florida.

Michel et al. (1975) concede that withdrawls from the Peace River coupled with low flow conditions could ultimately be harmful while arguing that withdrawls of 18.6 cfs from a low at Arcadia of 50 cfs will have minimal impacts. The authors seem primarily concerned with salinity changes.

Snedaker et al. (1977) point out that seldom is a river's flow reduced without water quality being reduced. The following scenario is taken from Snedaker et al. (1977).

> "Assuming, improbably, that the only change will be in the reduced supply of fresh water to the estuarine

> ecosystem, one may conjecture on the kinds of plants and animals which would replace those presently there. These species will be displaced due to increased salinity, reduction in the food supply, loss of a large area of low salinity, loss of nutrients, dissolved organics, and particulate matter, loss of large logs, branches, and other objects which serve as shelter, as well as food in their ultimate breakdown products, for estuarine organisms. Detritus-based food webs supporting rich benthic communities would be altered to phytoplankton which derive nutrients form offshore, high-salinity water, which is relatively poor in nutrients. This would support limited zooplankton populations, which would be fed upon by filter-feeding fishes such as anchovies and sardines. However, the populations would be smaller, and farther offshore. Estuarine fishes would be reduced, and oysters, clams, shrimp, menhaden, flounders, mullet, and blue crab would be reduced in size or would shift to estuaries where freshwater input was sufficient for their varied needs. The replacement clear-water species desirable to man would likely be pompano, kingfish and Spanish mackerels, stone crabs, bluefish, seatrouts and drums, and some seabasses and snappers, provided that some kind of adequate habitat and food were present. In contract, catfish, sharks, and rays would make these newfound habitats less desirable for some recreational uses by man. Also, a number of small, marine species, such as croakers, scads, and seatrouts might move into the area. These are presently underutilized by man, and could have commercial value. It should be stressed, however, that unless favorable bottom topography and an alternate food supply were available, there would be less reason for these organisms to come inshore than to seek other Gulf estuaries where freshwater effects offer adequate food. Thus, few permanent residents would be expected."

Phosphate operations would seem to have a large effect on the quantity of surface water reaching the estuaries. As suggested by Phillips proposed mining plan phosphate operations tend to create internal drainages - isolated basins with no discharge to rivers or creeks except during periods of heavy rainfall. While this semi-autonomous approach minimizes quality problems and maximizes recycling potentials, it has a tremendous impact on surface water flow.

Graphic analysis (Fig. 13) suggests that there is a one-to-one correlation between watershed area in square miles and mean stream discharge in cubic feet per second in this area of Florida. In other words, a rough rule of thumb is that every square mile of land tends to contribute an average of one cubic foot of water per second to local streams. Thus if a phosphate company were to remove 4 square miles from a

SLIMES

In the mining process, after the ore has been processed through washing and flotation steps, the sands, clays, clay sized particles of rock, and the amines and fatty acids used in flotation are piped to settling ponds. The particles settle quickly and clear water is decanted off the top. What remains in the impoundment is called slime - ultrafine clay, silt, and phosphate sand. The slime can contain up to 1/3 of the phosphorous contained in the original ore, and is usually 60% to 80% water. The material remains impounded for long, indefinite periods of time, and if the impounding dike should break, the fluid slime material enters surface waters, therein posing a threat to estuaries.

Between 1960 and 1971 at least 5 major fishkills on the Peace River were attributable to phosphate mining practices (Chapman, 1975). Two of these are well documented and resulted from escaped slimes. In March of 1967 a Mobil impoundment spilled 1,000-1,500 acre feet of slimes, which coursed 85 miles downstream, killing 91.3% of the fish in the affected portions of the river (Ware and Fish, 1969). Again in 1971, a Cities Service spill of 1 billion gallons of slimes proceeded 85 miles downstream, killing 75% of the fish in the lower river (Chapman, 1975). This second spill reached into intertidal and estuarine portions of the Peace River.

Excessive turbidities lasted for about a week after both spills, except for a three mile stretch of river near Ft. Ogden after the Cities Service spill. Turbid waters persisted in this intertidal area for six months until rains of Hurricane Agnes flushed the river (Chapman, 1975).

Healthy invertebrate populations were eliminated from areas that received spill effects, notable survivors being Oligochaeta, larval forms of Diptera, and some clams of the Sphaeridae. Invertebrate populations recovered after 8 or 9 months (Ware and Fish, 1969).

Fishes were either buried or suffocated when their gills became coated with clays. Primarily freshwater species were killed, but snook and mullet were among the dead.

Though the majority of slime spills never reach the estuary, at least one has and the potential exists for more spills of that same magnitude. Suspended fines settle out quickly when they reach saline water, but Chapman's evidence of high turbidities persisting for six months in intertidal areas of the Peace River is disturbing. These uppermost reaches of the estuary will suffer persistent turbidities, destruction of benthic and invertebrate populations, and fish kills whenever spills comparable to the Cities Service spill occur. Both detrital and plankton based food webs will be interrupted, but only in a local area, and recolonization by organisms unharmed in the estuary downstream should somewhat restore productivity in the affected area within a year of the spill.

The fine suspended particles which settle out in contact with the saline water, will increase the amount of phosphorous contained in the estuarine sediments.

Repeated spills in the same watershed could eventually have the cumulative effect of reducing the extent of upriver marshlands to the point that their water storage and nutrient trapping functions are impaired; and also reducing the water holding capacity of the river bed by filling in of pools and any quiet deep portions of the river. These in turn would cause the river to deliver more water, more rapidly, and more laden with nutrients to the estuaries.

[redacted]

FLUORIDE

Fluoride has been a historic factor in the Peace and Alafia river basins, the Alafia and Peace Rivers being the "only streams that drain the area of phosphate mining and... have received waste from the industry"(Toler, 1967).

Waste water from phosphate processing plants, as opposed to mining operations, can contain high concentrations of fluorides. Figures 10, 11, and 12 suggest the relative magnitude of fluorides in the Peace and Alafia Rivers in 1964 and 1965 (Toler, 1967).

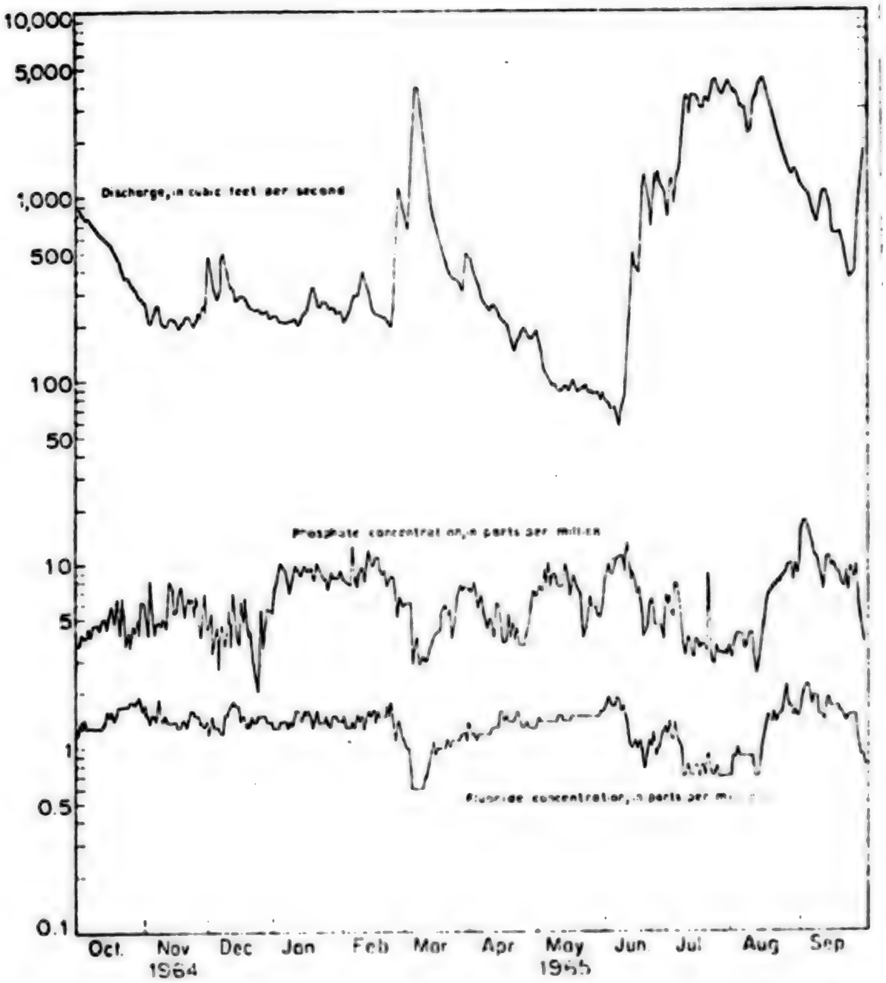

Figure 10. Discharge and concentrations of fluoride and phosphate for the Peace River at Arcadia from October 1964 to September 1965.

1342

(40)

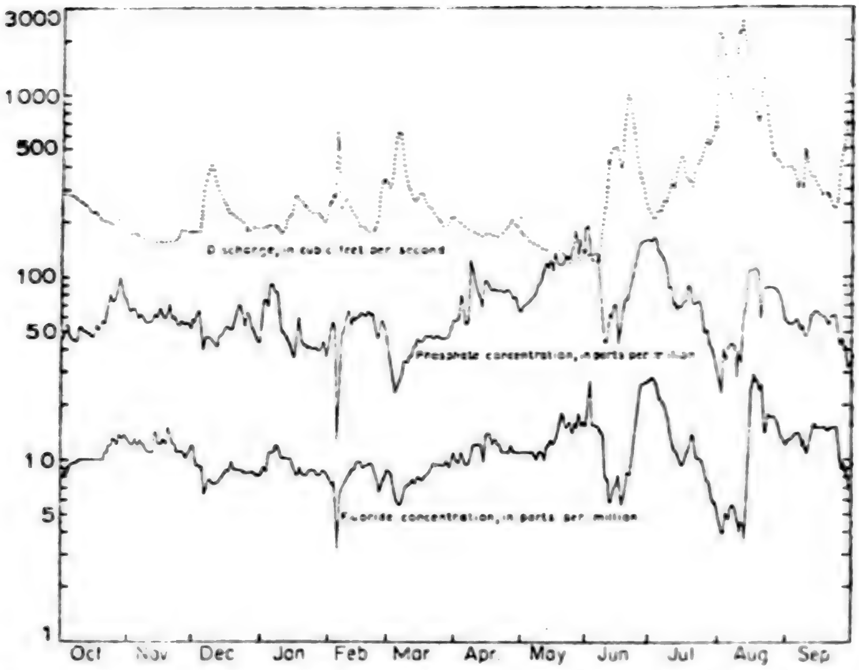

Figure 11-Discharge and concentrations of fluoride and phosphate for the Alafia River at Lithia from October 1964 to September 1965.

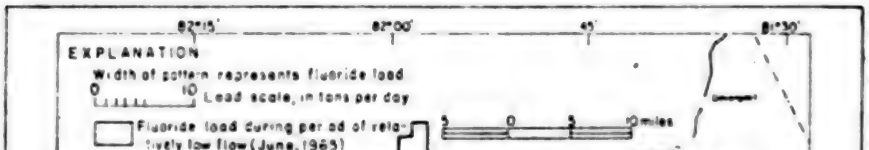
82°15'
82°00'
45'
81°30'
28°00'
45'
27°30'
EXPLANATION
Width of pattern represents fluoride load
0
10
Load scale, in tons per day
Fluoride load during period of relatively low flow (June, 1965)
Fluoride load during period of relatively high flow (September, 1965)
Numbers are fluoride concentration in parts per million, of sampling sites during June & September respectively
5
0
5
10 miles
0.5,0.7
3.1,5.2
3.1,1.1
2.9,1.1
2.6,2.1
1.3,1.4
17,19
17,24
32,26
7.8,11
11,14
7.3,7.0
2.6,4.2
0.2
0.8,0.9
2.0,1.7

Figure 12-Fluoride load in streams in Alafia and Peace River basins during periods of low and high flow 1965.

The phosphate rock mined in the Alafia and Peace River Basins is primarily fluorapatite $Ca_5(PO_4)_3F$ and contains 3.8 percent fluoride (Toler, 1967). Various byproducts of phosphate processing include silicon tetrafluoride, fluorosilisic acid, and hydrogen fluoride. Much of the fluoride used to be released to the air in the form of gaseous hydrogen fluoride, but this was found to be a significant form of air pollution (Martin and Taft, 1975).

One alternative was to install scrubbers, collect the fluoride and discharge it into water. This practice has resulted in a deposit of sedimentary fluorite, which may be unique, (Martin and Taft, 1975), and a new radioactive mineral, calcium uranyl flouride (Upchurch et al., 1976). In July 1973, 24,000 lbs a day were entering Tampa Bay from a single phosphate processing plant (Martin and Taft, 1975).

Toler (1967) suggests that aquatic life requires levels below 1.5 ppm; at those concentrations fluoride will not interfere with specified beneficial uses.

Waldhott (1973) characterizes fluoride as a systemic poison and describes its action as follows: "the strong affinity of fluoride for magnesium, manganese, and other metals, which causes it to interfere with the activity of many enzymes, can affect adversely the function of endocrine processes. Most thoroughly documented is an increase in the function of the parathyroid glands, which regulate the metabolism of calcium. Damage to the pituitary gland, the main regulator of water balance in the human organism, indicated by the occurence of polydipsia and polyuria (excess thirst and urination), is an early sign of fluoride intoxication."

Whether or not estuarine organisms suffer these effects has been difficult to determine.

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PHOSPHATE PROCESSING WASTES

Typically phosphate ore is refined by being treated with an excess of sulfuric acid, to form phosphoric acid, hydrated calcium sulfate, and hydrofluoric acid. The hydrated calcium sulfate, and soluble fluorides and phosphates are discharged into settling ponds to be stored indefinitely on the plant site (Lanquist, 1955). Subsequently, acid waters, thermally enriched waters, fluorides, and gypsum (hydrated calcium sulfate) are stored on the refinery site, escaping into surface waters at times of high runoff. The fluorides and sulfates have low levels of radioactivity. Gardinier's refinery is located on Hillsborough Bay at the mouth of the Alafia River. A study by Upchurch et al. (1976) documents the effects of these four wastes on the adjacent estuary.

A persistent clockwise gyre just north of the Alafia's mouth keeps discharges from Gardinier close to shore. Wastes from the plant enter the Bay via two drainage ditches, one north and one south of the gypsum mound.

Fluoride in the form of fluorite, having a low solubility in seawater, has settled out forming crusted deltas at the seaward end of both ditches. Waves break off small pieces of this crust and fluorite flakes are mixed in adjacent sediments. The fluoride delta supports only barnacles and bluegreen algae, with infauna occuring only where the delta has been covered by compacted organic material (Upchurch, et al., 1976). Fluoride in the delta sediments has exceeded levels toxic to aquatic fish, and the maximum levels for water not intended for public consumption. Due to its insolubility, the effects of fluoride in the estuary are localized. In response to regulations Gardinier has taken measures so that the fluoride escaping the refinery are decreasing.

Normal pH of Hillsborough Bay water is 7.9, and sediments adjacent to Gardinier have a mean pH of 4.6. Acid waters cause "decalcification of molluscs and crustaceans, destruction of emergent vegetation at the sediment water interface, bleaching of allochthonous algae, repulsion of seston, solution of suspended solids and particulate organics, and destruction of plankton and benthos" (Upchurch et al., 1976). Below pH 5 seawater contains little carbon dioxide for photosynthesis (Hobbie, 1974). Release of acid waters can be highly destructive to biota.

Gardinier's ditches have a mean temperature of 31.7° C while Hillsborough Bay's mean temperature is 23.2° C. Heated water stresses biota, and can reach lethal limits for species in the estuary. Thalassia suffers temperature stress between 30 and 33° C, slowing down or stopping growth (Jones, 1968). Unnatural temperature fluctuations can cause inopportune release of gametes by invertebrates (Horton and Bridges, 1974). Many estuarine organisms are living near the limits of their tolerance ranges and may be excluded from the estuary by additional stress such as thermal loading.

Gypsum is soluble and contains small amounts of radium 226. Though there is no evidence of water adjacent to Gardinier being radioactive, gypsum is available in the estuarine sediments over 60 hectares and can be released with its radium into the water column, possibly affecting the estuarine biota. These 60 hectares of gypsum sediments have low densities of benthic infauna, and a scarcity of fish because vegetation and cover are lacking.

Numerous phosphate refining or processing facilities are located in the upper watersheds of the Peace and Alafia Rivers. Presently only a few are located adjacent to estuarine waters - notably Gardinier on the Alafia. The Gardinier area supports a smaller diversity (50 species) than any other studied site in Tampa Bay (Upchurch et al., 1976). Densities of intertidal organisms are 4 - 10 times lower in the area affected by Gardinier's wastes than in comparable areas of Tampa Bay. It can be predicted that estuarine areas adjacent to any other phosphate processing facilities will experience similar ill effects.

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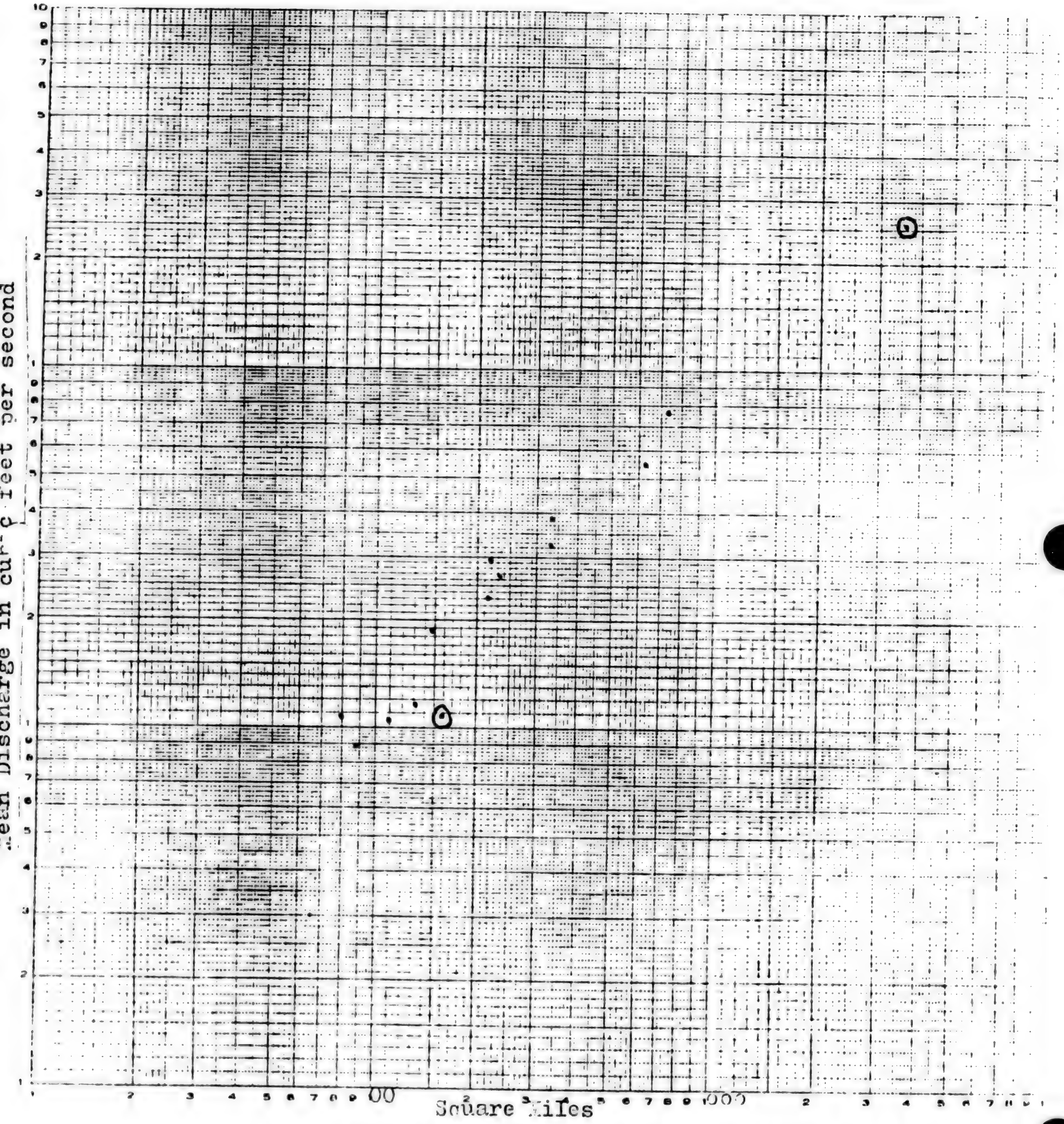

Fig.13-- Area:Discharge, Selected Streams of S.W. Fla.

Average discharge in cubic feet per second, area in square miles

Circled points lie in the Peace River system.

data from Heath and Wimberly, 1971

watershed in this area, you could expect average streamflow to drop 4 cfs. This would be more than two and one half million gallons a day. Phosphate holdings appear to total more than 400 square miles (SWFWMD, 1976). If this property is withdrawn from existing watersheds by creating internal drainages, then the amount of freshwater it removes from the estuaries of the area would be equivalent to the flow of the Myakka River. Thus, on a conceptual level, the ongoing technique of internal drainages threatens as many estuarine resources as one could find in the Myakka River estuary.

It could be argued that freshwater discharge from phosphate operations during periods of heavy rainfall and increased runoff from drainage projects such as Cow Pen Slough compensates for the internal drainages and decreased runoff from phosphate operations. If the increased runoff and discharge was used to minimize low flow problems, this might be the case; but human systems in this area tend to remove water from surface storages when it is dry and void water to surface flows when it is wet. This pattern accentuates the problems of both low flow and high flow conditions. The estuary is subjected to wider and wider fluctuations in water quantity as man's perceived needs for water drive a positive feedback function that makes dry rivers drier and wet rivers wetter.

Thus it may be seen that the roles of timing and quantity of surface water flows to estuaries are at least as significant as water quality. Too much is known about diverting water from estuaries on the Nile, Colorado, and Everglades to allow water quality questions to eclipse those of quantity and timing.

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APPENDIX C

A report on habitat associations and wildlife values of unreclaimed phosphate mines

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WILDLIFE VALUES MAY BE NEGATED BY PHOSPHATE MINE "RECLAMATION"

By John B. Edscorn

INTRODUCTION

Little realized by the general public, the settling basins and abandoned pits of central Florida phosphate mines commonly have great wildlife values. These values often enormously exceed those of the same properties before they were mined. By comparison, perceptive observers liken the results of current reclamation (land-leveling) measures to deserts. Since reclamation is mandatory, the eyebrow-lifting protest of naturalists merits serious attention and, it is hoped, corrective legislative action.

This report addresses representative habitat successions and attending wildlife values in unreclaimed phosphate pits and settling basins, contrasting these with conditions that obtain on mined lands after they are ostensibly reclaimed by land-leveling operations. In recognition of the extraordinary wildlife values in settling basins, they are given attention herein. Suggestions favoring wildlife include (a) modification of the 1975 Florida law which required reclamation of mined-out lands, and (b) an indication of the desirability of official protection and management to assure the enhancement and preservation of wildlife values in perpetuity.

A BRIEF BACKGROUND

Central Florida has for many years produced most of the phosphate that is used by America and much of the world in fertilizers and a myriad of other products. Much commerce and employment derives from this, making the phosphate industry an important element of Florida's general economy. For such reasons the heavy-handed mining methods are at least begrudgingly accepted by the public. An understanding of these mining procedures and their consequences --environmental as well as esthetic--is germane to this report.

EARLY AND RECENT MINING CONSEQUENCES CONTRASTED

Earlier central Florida mining operations were relatively small and primitive; environmental disturbance was minor, and Nature long ago restored order. Surface irregularities remain, but large trees (oaks, pines and other native species) and natural undercover otherwise bestow a normal, natural appearance pleasant to the eye. The scale of mining escalated immensely, as did environmental disruption. A modern mine is not just a giant enlargement of its pioneer image; its impacts and long-lasting aftermaths are so chaotic it may be impossible to restore conditions identical to those of nearby unmined lands, or to recreate significant wildlife values in whatever does emerge after mined-out lands are leveled out by "reclamation." However, unleveled mines do undergo rapid vegetative regeneration with important food and habitat benefits to wildlife.

TYPICAL MINING METHODS

The actual mining of phosphate in central Florida is accomplished by great draglines. They remove the "overburden" of soil layers which lie above the phosphate stratum (piling the overburden aside), then they dig out the exposed phosphate "rock" and dump it into improvised sumps. There high-pressure streams of water soon liquify it to a consistency which permits its delivery by pumps through pipelines to the processing plants. Wells tap vast amounts of water from the Floridan Aquifer for this and other steps in the processing, as well as for conveyance of waste to "slime pits."

SETTLING BASINS ("SLIME PITS")

In association with Florida phosphate mines are vast settling basins (a system of these may cover a number of square miles). Although commonly called "slime pits," they are (except in cases where old phosphate pits are used) typically expansive, above-ground impoundments contained by massive dikes, and are not pits at all. Ultimately these basins accumulate an enormous volume of colloidal material in aquatic suspension--"slime"--a tenacious clay waste which requires years to solidify (continuing research eventually may obviate the need for slime pits). Paradoxical as it may seem, these awful creations make wondrous wildlife areas. For one thing, stands of trees engulfed in the impoundments have often afforded rookeries for thousands of birds, including endangered or threatened species.

POPULAR SENTIMENT REGARDING PHOSPHATE MINES

As may be visualized from foregoing descriptions, phosphate mining produces much-resented topographical changes, and these cover large areas in central Florida. During and shortly after dragline operations the ridges of discarded overburden remain in raw disarray (such tortured "moonscapes" are a chronic public irritant), but even long-abandoned mines offering an enjoyable, natural appearance do not please everyone. Often the very people who regularly frequent the latter areas for fishing and other recreation will echo the popular complaint to the effect that the mine companies should "clean up their mess, and put things back." For one thing, the ground isn't flat (that stirs a human compulsion for filling in low places and tidying up surface irregularities) and, since the prior countryside can't be "put back," land-leveling is popularly equated with reclamation. Prevailing opinion coalesced in a demand for land-leveling, culminating in passage of the 1975 reclamation law.

NATURALISTS OPPOSE INFLEXIBLE LAND-LEVELING RESULTS OF THE LAW

Excluding the phosphate industry, most opposition to mandatory reclamation (when it primarily produces land-leveling) is voiced by naturalists. This, coming ironically from those who so lament loss of long-loved natural areas caused by destructive mining, can be seen to represent valid insight and an informed appraisal of realities. In this view, the creation of bleak, level expanses for little purpose other than to make mined-out areas flat again is generally deplored; the unreclaimed mines are often considered more important to wildlife. Unusual as it may seem to ascribe great natural values to such mundane creations as phosphate mines, naturalists who know them best point out that extraordinary wildlife areas have traditionally been a fortuitous result of mining operations.

HABITAT SUCCESSIONS AND WILDLIFE VALUES IN UNRECLAIMED MINES

Examples of central Florida phosphate mines vary considerably. For this illustration a few reasonably representative mines of various ages are portrayed (each example is numbered, and continuing paragraphs related to a given location are denoted by letters).

(1.) EARLY-DAY MINES were delightfully quaint by today's standards. Animal-drawn scoops once took phosphate from the edge of Lake Hancock (near Highland City, Polk County), for instance. Old sunken barges can still be seen in the lake and in Peace River; their size made them difficult to handle in the upper Peace, yet a modern dragline's shovelfuls would promptly bury them! Climax vegetation long ago restored normal natural values to the oldest mines. More recent developments (agricultural, residential or commercial--including in some cases the re-mining of areas by more efficient means) have so

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clouded the picture that further description would be irrelevant.

(2.) THE "CHRISTINA" AREA between Lakeland and Mulberry (Polk County) offers examples of slightly more recent but superannuated mining remains. Virtually ignored for decades, it already had an appealingly natural aspect (large trees, normal understory, with all expected wildlife values) when I first saw it in the mid-1940's. It, too, has been altered considerably in recent history. A public park in the '60's, and more recently a very desirable real estate development, its changes have obliterated much, but I have known the area for over 30 years and can easily describe its prominent features before it was turned into a smart residential address (that in itself will reveal its appeal, as does the fact that it was long popular for field trips by biology classes and naturalist groups).

(2a) CHRISTINA FEATURES haphazard distribution of its hills of overburden (hills and pits conform to no set pattern or shapes), and most of the area between the hills was so high that it never became filled with water. Apparently a favorable soil situation was left in many areas; large oaks crown the hills and the pinewoods featured such habitat-selective species as Bachman's Sparrow (*Aimophila aestivalis*). In one hammock situation fine examples of the green-flowered terrestrial orchid, *Habenaria lacera* already flourished at least fifteen years ago. Such indicators reveal the extent of regeneration accomplished by Nature--in the absence of land-leveling reclamation.

(2b) **NATURAL HABITAT AND WILDLIFE SUCCESSIONS AT CHRISTINA** are subjects so obscured by time that their reconstruction in the absence of continuing accounts by witnesses is largely conjectural. Here one is reminded that overburden differs from mine to mine and varies considerably according to the composition, fertility, acidity, etc. of the soil types--of many geological ages--which end up "on top" when turned topsy-turvy in the piling up of the hills. A familiar succession of vegetation on overburden typically involves hardy weeds, grasses and other plants of disturbed lands. Coarse shrubs eventually appear, as trees finally do if the overburden slopes are not too precipitous. Whether all of this took place at Christina, as at contemporary mines, can be disputed. Perhaps tree seedlings gained footholds almost immediately. In any case, this area today is so beautifully wooded that a stranger would never suspect it had ever been mined!

(2c) **ALONG THE POOL EDGES AT CHRISTINA** the ubiquitous cattail, a renowned pioneer of phosphate pits, was and is largely excluded by vertical drop-offs into the depths. Largely absent are damp areas which attract evening primrose, elderberry, willows and the like which are common at other mines. Farther up from the water wax myrtle and other shrubby growth typical of mines may have soon been accompanied by the seedlings of trees, primarily oaks, which then grew to present dominancy which shades out much of the sun-loving growth below.

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(2d) WILDLIFE AT CHRISTINA (before recent developments) included all or virtually all fish, reptiles, mammals and birds of similar habitats in surrounding un-mined lands. Since avifauna often is an ideal indicator of the completeness of habitat restoration, I will list a few representative species which were normally seen on typical samplings of the pinelands, oak groves and ponds: Pied-billed Grebe (*Podilymbus podiceps*), Double-crested Cormorant (*Phalacrocorax auritus*), Anhinga (*Anhinga anhinga*), Red-shouldered Hawk (*Buteo lineatus*), Osprey (*Pandion haliaetus*), American Kestrel (*Falco sparverius*), Bobwhite (*Colinus virginianus*), all of the *Ciconiiformes* order which are native on other central Florida fresh water bodies, Common Gallinule (*Gallinula chloropus*), American Coot (*Fulica americana*), Killdeer (*Charadrius cociferus*), Common Snipe (*Gallinago gallinago*), various *Larids* which are normal elsewhere in the region, Mourning Dove (*Zenaidura macroura*), Ground Dove (*Columigallina passerina*), Yellow-billed Cuckoo (*Coccyzus americanus*), Screech Owl (*Otus asio*), Great Horned Owl (*Bubo virginianus*), Chuck-will's-widow (*Caprimulgus carolinensis*), Common Nighthawk (*Chordeiles minor*), Belted Kingfisher (*Magaceryle alcyon*), six *Picformes* (including notable numbers of Red-headed Woodpeckers, *Melanerpes erythrocephalus*, a declining species locally), Great Crested Flycatcher (*Myiarchus crinitus*), Eastern Phoebe (*Sayornis phoebe*), Blue Jay (*Cyanocitta cristata*), Fish Crow (*Corvus assifragus*), Tufted Titmouse (*Parus bicolor*), House Wren (*Troglodytes aedon*), Carolina Wren (*Thryothorus ludovicianus*), Mockingbird (*Mimus polyglottos*), Catbird (*Dumetella carolinensis*), Brown Thrasher (*Taxostoma rufum*), American Robin (*Turdus migratorius*), Hermit Thrush (*Hylocichla guttata*), Eastern Bluebird (*Sialia sialis*), Blue-gray Gnatcatcher (*Polioptila caerulea*), Ruby-crowned Kinglet (*Regulus calendula*), Loggerhead Shrike (*Lanius ludovicianus*), Solitary Vireo (*Vireo solitarius*), White-eyed Vireo (*Vireo griseus*), Yellow-throated Vireo (*Vireo flavifrons*), Yellow-throated Warbler (*Dendroica dominica*), Pine Warbler (*Dendroica pinus*), Ovenbird (*Seirus aurocapillus*), Common Yellowthroat (*Geothlypis trichas*), Eastern Meadowlark (*Sturnella magna*), Red-winged Blackbird (*Agelaius phoeniceus*), Boat-tailed Grackle (*Cassidix mexicanus*), Common Grackle (*Quiscalus quiscula*), Summer Tanager (*Piranga rubra*), Cardinal (*Richmondena cardinalis*), American Goldfinch (*Spinus tristis*), Rufous-sided Towhee (*Pipilo erythrophthalmus*), and at least eight sparrows (*Fringilidae*), notably Bachman's Sparrow (*Aimophila aestivalis*). This list does not include species seen only in migration (migrants recorded at Christina would vastly inflate the list); it is confined to resident species (winter, summer or permanent). To avoid lengthy repitition hereafter, this list will be referred to and applied to other areas with appropriate additions and subtractions being noted.

(3.) SADDLE CREEK PARK AREA (Aldine Combee Park) is a well-known abandoned mine site lying a few miles east of Lakeland. I watched it being mined in the late 1940's and have monitored its avifauna very thoroughly, beginning in the late 1950's (but especially over the past 15 years). In consequence, I have witnessed its habitat and wildlife values on an intimate and frequent basis. This old mine in a single decade became a valuable wildlife area, particularly along its east side and in its water-filled pits. An Audubon sanctuary for a time, it became a county park which is now heavily used by the public, yet it is still very popular with naturalists.

(3a) SADDLE CREEK PARK is basically similar to most recent mines, albeit smaller than many. Its pits and overburden ridges are not unlike those which are seen throughout the phosphate-producing area after a decade or so has elapsed from the time of mining. An important difference is seen along the east side of the park. There, undoubtedly because of the proximity of a large, undisturbed swamp forest (which served as ready source of seeds), rejuvenation was amazingly swift. Large native trees such as Hackberry, Red Mulberry and various oaks cover much of the higher terrain; within a decade they were large enough to begin shading out much of the dense ground cover, and as this continues an open, park-like situation is created under the more mature stands. Exotic species such as Brazilian Pepper attain great size here, too, but eventually a dense tree canopy above them limits their success. In areas more distant from the tree seed supply (or where unfavorable soils may prevail), a nearly impenetrable, waist-to-head-high cover of coarse plants is the rule. *Bidens*, Caesar's Weed, Ragweed and many others, sometimes entangled with Balsam Apple, Smilax and other vining growth, make a hostile impediment to man's entry, but valuable food and cover for wildlife. Ultimately the weedy cover is also eliminated by trees. Then an entirely esthetic ground cover of ferns and other shade-loving plants appears. These have long been established in some areas.

(3b) THE PIT BANKS ALONG THE EAST SIDE OF SADDLE CREEK PARK also afford a provocative contrast with those further removed from the seed supply (there is an important comparison here, with reseeding implications for present-day mines which are distant from natural sources). The willows (typical pioneer trees of old mine shores) are complimented by maturing stands of maples and other bottomland trees--in sharp contrast to their sparsity or absence on other shores of the park. Away from the east side of the park continuing "clean-up" endeavors by park personnel have denuded the shallows of cattails and scalped virtually all trees from the shores--to allow availability to the water for fishermen (without habitat for minnows the larger fish are no longer caught as they once were) and to lend a more "civilized" appearance. There has been some tree-planting in recent years--often of trees of debatable desirability--but this has primarily involved roadside areas, not isolated overburden hills. At the latter locations

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trees have been slow to return; a situation typical of many or most old mines of steep-sided ridges and often-unfavorable soils, especially when no nearby seed supply exists. The ridges are vegetated (typically wax myrtle replaces the smaller plant cover), but not yet by climax trees. There are many islands in the pits which have *not* been subjected to periodic bull-dozing. Here, too, the familiar willow and wax myrtle cover of the ridges is dominant. These islands have special significance: they support a permanent Limpkin (*Aramus guarauna*) population in seemingly atypical habitat; probably the first such colonization on record!

(3c) A WILDLIFE LIST AT SADDLE CREEK PARK, incomplete but representative, decidedly reflects regeneration of natural values on the eastern side (near the native swamp). Elsewhere the greatest values are in the waters and shores. Probably all or most expected fish species (including exotic tilapia) are now extant, judging by catches I have witnessed for over 20 years. Various turtles are common, and large alligators are occasionally seen. Snakes are seldom seen (possibly reflecting alligator predation in the case of water snakes); species I have recorded recently are: Cottonmouth Moccasin, Indigo Snake and Yellow Rat Snake. Common mammals include: Hispid Cotton Rat, Cottontail and Marsh Rabbit, Gray Squirrel, Armadillo and Raccoon, in about that order--River Otters are rarely seen, as are Bobcat tracks. In the 1960's large flocks of ducks (primarily American widgeon, *Mareca americana*, and Blue-winged Teal, *Anas discors*) and thousands of

American Coots (Fulica americana) were normal in winter, but irradication of aquatic weeds eliminated their food supply.

(3d) AVIFAUNA AT SADDLE CREEK PARK is so rich and varied (and so indicative of very successful habitat restoration) it deserves particular attention. This park is well known among Florida birders; in fact, during fall migrations--when birds in passage swell the list amazingly--visitors from many parts of Florida and even from out-of-state make pilgrimages to this site. I have personally recorded 194 species there, and other reports raise the total to about 200 (and the park doesn't even have a large lake to boost potentials)! This bird list exceeds that of any other comparable location in the Florida interior--classic illustration of the appeal for wildlife old phosphate mines can have, with no reclamation by man. Had this outstanding area been leveled again it would have had much less natural value, as can be seen in long "reclaimed" areas.

(3e) THE SADDLE CREEK BIRD LIST would include all species contained in the Christina list (2d), except that Red-headed Woodpecker and Summer Tanager, while seen annually, are not summer, winter or permanent residents, and Bachman's Sparrow is unrecorded. Additions to these three "resident" categories would include (beside various bird species already mentioned for Saddle Creek Park above): Wood Duck

(*Aix sponsa*), Turkey Vulture (*Cathartes aura*), Black Vulture (*Coragyps atratus*) (both vultures are also seen over Christina, of course, but do not roost on that property), Sharp-shinned Hawk (*Accipiter striatus*), Bald Eagle (*Haliaeetus leucocephalus*), King Rail (*Rallus elegans*), Spotted Sandpiper (*Actitis macularia*), Barred Owl (*Strix varia*), Cedar Waxwing (*Bombycilla cedrorum*), Red-eyed Vireo (*Vireo olivaceus*), Prothonotary Warbler (*Protonotaria citrea*), Parula Warbler (*Parula americana*), Prairie Warbler (*Dendroica discolor*), Palm Warbler (*Dendroica palmarum*), Swamp Sparrow (*Melospiza georgiana*) and Song Sparrow (*Melospiza melodia*). In addition to these birds, a most impressive array of other species can be seen here annually as migrants or visitors from nearby areas, and a number of accidentals and rarities have occurred. Outstanding among the latter are Roseate Spoonbill (*Ajaia ajaja*), White-winged Scoter (*Melanitta deglandi*), Short-tailed Hawk (*Buteo brachyurus*), Yellow-bellied Flycatcher (*Empidonax flaviventris*), Winter Wren (*Troglodytes troglodytes*) and Swainson's Warbler (*Limnothlypis swainsonii*).

(4) ORANGE PARK AND TENEROC MINES (adjoining properties a few miles northeast of Lakeland) contain representative examples of phosphate mines of recent history, and both are still in operation. Here one can see the nadir in visual effects as new mining--and reclamation--progresses, but here too is one of the zeniths in wildlife areas of

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the region. In addition to pits of various ages (very popular with fishermen and duck hunters, sometimes clandestinely), the settling basins run the gamut of variations--old mined-out pits as well as diked un-mined lands are used for retention of slime--and they cover a number of square miles. In some areas extensive stands of trees were engulfed in the slime basins. Great numbers of wading birds have used these trees for nesting and roosting areas, as have cormorants and Anhingas; at times thousands of such birds gather here. Gradually horizontal limbs fall from most trees, and their use by the birds is lessened. Even so, the skeletonized trees, after years and years, are still used by many birds for nest and roost sites.

(4a) ONE LARGE SLIME BASIN AT ORANGE PARK MINE affords an interesting example of willow growth, miles of it, which has reached a size suitable for the same kinds of nesting and roosting birds that used the trees which earlier were killed by the rising slime. Thus, as too many limbs were lost from the dead trees, the new trees have provided a welcome new sanctuary. The really interesting aspect of this vast willow area is that is is growing on the surface of slime many feet deep! Years ago this basin was solidly covered with the usual cattails atop the vast expanse of slime (a familiar sight at any slime basin; as soon as the water above the slime is shallow enough, the cattails begin to grow). Typically, as the slime level rises the cattails rise with it, unless the water above the slime gets too deep. In this instance, water was then long withheld. This compares to the condition at any settling basin when its use is discontinued. The surface, no longer constantly maintained by a supply of water and slime, begins to dry off slightly. Then the willows invade, and as the surface continues to harden and dry it supports various other shrubby growths. This is an impenetrable mess in the eyes of most humans, and, indeed, should a man attempt to enter such areas and fall through the thin surface crust (as I have!), he is into the horror of the worst of all quagmires. However, wild creatures can walk where man cannot; much wildlife thus thrives in these quaking no-man's-lands of "impenetrable mess."

The difference at Orange Park is that surface water again was pumped into this basin. Much of the now-well-established growth was killed, but not most of the willows. Having attained a good size, they have managed to hang on...presto!, a ready made rookery and roost site, complete with standing water around the trees (as required by wading birds). Now, far out from the dikes, far out on the reflooded slime surface, wading birds have a world of their own.

(4b) OTHER LONG-USED SLIME BASINS AT ORANGE PARK are almost solidly covered with cattails now. There, the huge duck flocks are largely excluded; they concentrate in the dwindling open areas, or move to other, newer basins with open water nearby. But what is left in the veritable sea of cattails now? Rails by the thousands! This area has produced the highest count of Soras (Porzana carolina) in nationwide bird counts, and King Rails must inhabit these great expanses in enormous numbers, too (though being less vocal, their numbers can only be guessed at). What else? Tremendous numbers of Common Yellowthroats and Swamp Sparrows in winter. Life is abundant in these "wastelands," as is evidenced by the wintering Marsh Hawks (Circus cyaneus); this declining raptor concentrates in the settling basins as in no other habitat of the entire phosphate region nowadays.

(4c) NEWER SETTLING BASINS AT ORANGE PARK are gradually filling. Where pipelines discharge into these areas the slime has built up to the surface, and cattails are covering this. Far from the slime source the water is still very deep; in the cool months thousands of ducks and coots cover the surface. Hundreds of White Pelicans (Pelecanus erythrorhynchos) have become normal visitors; they roost on islands with hundreds of cormorants and Anhingas (this area also produces record Anhinga numbers in nationwide bird counts). In between the shoal end and the deep end there is a gradual slope to the slime which is oozing its way inexorably toward the depths. In this area I counted 200 Gadwalls (Anas strepera) in December, 1976, the most I have ever seen, and in 1967 I saw--in a single flock--over 600 Hooded Mergansers! Anyone familiar with waterfowl in Florida will find this almost incredible, as did the many witnesses--even as they beheld it. Many other ducks frequent this zone, and right where the slime is at the surface, but not yet cattail-covered, the Northern Shovelers (*Spatula clypeata*) and teal half-swim-half-plow along with heads submerged as they strain food out of the slime. I counted a remarkable 300+ Green-winged Teal (*Anas carolinensis*) here in December, 1976, and have seen shovelers in similar abundance. Overhead one sees the occasional Bald Eagle--very rarely the thrilling, endangered Peregrine Falcon (*Falco peregrinus*)--attracted by the waterfowl assemblage. With luck, otters and bobcats will be seen. Slime basins are wildlife paradises; they merit study for preservation (a continuing water supply would be one management tool which could vary the conditions as desired).

(4d) WILDLIFE VALUES AT ORANGE PARK AND TENEROC MINES are very high (typical of central Florida phosphate mines). Without resorting to exhaustive species lists--much having already been covered--it is necessary to say only that Orange Park's species, when contrasted with those of Saddle Creek Park, would reflect a paucity of regenerating hardwoods and a plethora of open water and marshes. Since birds are such excellent and (in most cases) obligingly visible indicators of ecological health, and since field ornithology is my strongest point as a naturalist, I have emphasised avifauna in my descriptions. I am sure from my own observations, that other vertebrates abound in phosphate mines, but their unobtrusive ways and inaccessible haunts make them far more difficult to assess in such areas.

BEAUTY

As "beauty is in the eye of the beholder" (often considerably conditioned by others), so the generally unloved phosphate mines are cherished by naturalists--and not at all in the absence of esthetic feeling. Three years ago, driving atop a great settling basin dike, I became aware that our guest from England was overwhelmed with the exhilaration of driving at such a height with immensity of space, abundance of life, solitude and the strange beauty of that vast phosphate area all about us. "We have nothing at all like this at home," he explained. However, being under the spell of the English countryside myself, I made the obvious comparison. "Yes, but we are so crowded," he went on; "Some day you will be, too, and places like this will be priceless." What we take for granted, he was seeing for the first time (and with no inkling beforehand of where we were going). I told him that such sights were not appreciated here. He was long silent...then, "They just don't know...they don't understand." That wise, elderly man of the old country was appalled that such areas were not being saved as splendid nature refuges. Then we, too, were long silent.

RECLAMATION

Various phosphate companies experimented with land-leveling and replanting projects for many years before reclamation became mandatory. Despite the obvious benefits in public relations which derive

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from reclamation of mined-out lands in line with popular ideas among the citizenry (with implied prospects of eventual land sales on the part of both sides), such measures evidently are not economical and results have not been impressive. Planted pines and pastures have done well enough, but dreams of orange groves on old mine lands proved to be chimeras for the most part (it can be done, but it is not a practical undertaking unless soil and water conditions are uncommonly favorable--and that isn't how re-leveled overburden usually ends up). What passes for topsoil in many areas before they are mined might not be much, but when it ends up on the bottom and some gummy stuff from a sea bottom of ages ago ends up on top in the "reclamation" land-leveling procedure...Nature must start over again.

The normal disposition of soil types in the stratifications which cover the phosphate-bearing stratum is difficult or impossible to restore after mining, and the deeper the excavations the greater the overburden and the greater the reclamation problem. Thus, what is produced by mere land-leveling is ground that is again flat--albeit often unsatisfactory--except to the extent that conventionally level terrain satisfies the public. What will grow there, how long it will take, and what wildlife will live in the result is unclear.

Various older examples of reclamation exist, but there is not much to report in the way of wildlife values on such property when compared with old mines. Planted pines and pastures are just that, monocultures of little wildlife value. For example, the "Pinewoods Sparrow" (Bachman's Sparrow of peninsular Florida) desires more than planted pine trees; it requires a natural combination of grasses and cover such as palmetto for its food and protection. Likewise, other pinewoods species are conspiciously scarce or absent in most examples of planted pinelands on re-leveled mine sites.

By far the most familiar result of reclamation is simply leveled land. North of Lake Parker (Lakeland) is a vast, rather desert-like plain which is the product of a much-touted reclamation project where mining took place well over a decade ago. Over the years I have seen a few rabbits along the edge, and once I came upon a red fox (introduced here in the'40's and apparently displacing the native gray fox). Other life, including the revealing dearth of bird life, is so scarce one must almost see such areas to understand. How such "reclamation" is to be preferred to abandoned mines is baffling, since the product is still flat land thinly covered by tough, tolerant plant types. This suggests that the soils which comprise the surface now may be hostile to wildlife regeneration for many years to come; even a reseeding program might not restore native growth in normal balance.

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An obvious help in the first place might be the setting aside of topsoil and shallow subsurface soil layers when overburden is being removed by draglines; then the "right" soil might eventually be put on top again. The industry realizes this, but there are many complications (one is familiar to anyone who has ever dug a hole, and then tried to use the same dirt to fill it--some is "gone"). Top soil comprises a small portion of the excavated material at a mine, especially if the phosphate vein lies deep; redistributing this evenly after reburying objectionable soils is a lot to expect of heavy-equipment operators. One area where rich soil is being spread over leveled lands beside a highway makes for mistaken conclusions among passersby.

MODIFICATION OF THE RECLAMATION LAW

As is so often the case with engineering "solutions," limited objectives produce limited results. The primary objective sought by citizens in the pressure for phosphate mine reclamation was land-leveling. Mined-out lands are considered "wastelands." Somehow these people don't look very closely at the barren grounds now being produced by land-leveling. All is level again, and that solves that, in the prevailing view. The putative land waste left by the abandoned mines has now been resolved; no more "moonscapes" of little or no value for future, conventional development. Some people are also pressing for reclamation of very old mines; those outside of the purview of the present law. Such people are unaware of or unsympathetic to the great wildlife values of many old mines. The thrust is toward level land suitable for human use again. Recent warnings concerning the dangerous radioactivity in homes located on old mine lands compound the problem, but making the rounds are firm assurances that this will be solved. In the meantime we are making more bleak flatlands at the mines instead of the former wildlife-rich "no-man's-lands" (the fact that they have always been so cut off from civilization has been a vital wildlife value in itself). And if the trend continues, the old mines will be leveled, too.

Plainly it is time for very serious reconsideration by governmental leaders. A truly comprehensive study of the situation is essential; one which recognizes and seeks to preserve important wildlife values--realizing just how priceless they will be in the future, especially in the multi-city complex of Polk County where most other lands will foreseeably be covered with buildings and people. The Englishman who saw our mines immediately knew that these were lands which should be left alone, left in trust for the day when everything will be "so crowded." It is to be hoped that Florida's law can be modified to create, not destroy, wildlife values on mined-out phosphate land.

WILDLIFE REFUGES

A naturalist cannot contemplate a vast expanse of mined-out lands and settling basins without realizing their value as wildlife refuges.

Problems are many. To maintain water in an above-ground basin would mean continuing to tap the aquifer with energy-consuming pumps, for one thing (use of shallow-aquifer water from nearby phosphate pits could at least relieve the Floridan Aquifer, if that became desirable, and windmills could do the pumping). Since settling basins have such exceptional wildlife attractions, especially with continuing losses of natural habitat elsewhere, preservation of these values leads inevitably to consideration of official refuges on important mines. The basins and the nearby old phosphate pits must be regarded as a unit (for, say, a water supply, as described above, and for many other reasons). Management procedures would basically involve maintaining optimum water levels for wildlife in the slime basins. In the old pits experiments with the seeding of native trees in natural balance might reveal ways to enhance habitat values on islands of overburden as well as on the dike slopes of slime basins. Since seed sources are often too far away for this to occur naturally in the reasonable future, and since the example at Saddle Creek Park definitely supports belief that seeding can very quickly restore pit areas, such experiments are unquestionably needed.

SUMMARY

Central Florida phosphate mining leaves results which are widely regarded as unacceptable eyesores. The 1975 Florida law requiring reclamation of mined-out lands is a result of this sentiment, but in application

it is producing flat, unnaturally constituted (often poor) soil areas and wildlife habitats over vast expanses. Naturalists decry the loss of phosphate areas since these historically were a fortuitous source of new wildlife habitat of overwhelming preference when compared with lands now being produced by "reclamation." Reclamation is not only costly (to phosphate consumers) but is enormously insensitive to wildlife values. Some examples of natural restoration at old mine sites have been very impressive, while land-leveling has thus far left grave questions unanswered. A comprehensive study is needed to demonstrate to legislators the desirability for amendment of the reclamation law to preserve wildlife values. To assure that such values are in fact preserved in perpetuity, important phosphate areas should be considered for protection and management. In such preserved mines the slime basin water levels might be maintained by wind powered "pumps," possibly using water from adjacent phosphate pits, and experiments involving balanced reseeding of native trees might reveal ways of hastening restoration in all abandoned mines.

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APPENDIX D

Reports on the Flatford Swamp and Tatum Sawgrass areas in Manatee County

Prepared by

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Sarasota, Florida

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FLATFORD SWAMP

Flatford Swamp is a major but seldom named landform clearly visible on the popular 1:500,000 False Color Infrared Map of Florida.

The southernmost portion of the swamp lies roughly 1 mile NNE of Myakka City in Manatee County. It is at this point that the Flatford Bridge on the Myakka City - Wachula Road crosses the Myakka River.

Seven named tributaries add their flow to the Myakka River in this confluential swamp: Ogleby Creek, Boggy Creek, Coker Creek, Sand Slough, Youngs Creek, Long Creek, and Maple Creek. The swamp itself is arrow-head shaped with the tip pointing southward. The majority of the swamp lies below the 40 foot contour. The area of the swamp below the 40 foot contour is about 3 1/3 square miles, or 2,133 acres. An additional 250 adres of the swamp lies above the forty foot contour, resulting in a total acreage of 2,383. U.S.G.S. Quadrangle maps were used to determine elevation and area for Flatford Swamp.

Little has been written about the hydrologic functioning of Flatford Swamp. In Report of Investigations No. 53, *Low Streamflow in the Myakka River Basin Area in Florida*, Flippo and Joyner speculate that most of the water stored in the swamp is lost by evapotranspiration. "Some of the direct runoff from showers in the headwaters of the Myakka River is temporarily stored in a swamp just north of Myakka City. Most of this stored water is believed to be lost by evapotranspiration, because the piezometric head in the Hawthorn Formation is too high to permit recharge and because little runoff from sporadic showers is measured at the gaging station at Myakka City. As a drought progresses and the water table falls, the Upper Myakka River will cease flowing, drying up altogether in its shallower reaches."

Traversing the swamp on June 1, 1977, prior to the onset of the rains and the driest time of year, water was found to be rather uniformly 1½ feet deep with many deeper ponds and pockets, and also shallower areas along the edges. This suggests that water is stored in the swamp in great quantities, not lost to evapo-transpiration. And it suggests that the immensity of the swamp's storage capacity can absorb the runoff from showers upstream, yielding no increased streamflow downstream.

Flatford Swamp is the most extensive undisturbed wetland in private ownership that we are aware of in Sarasota and Manatee Counties. Although the land is used as native pasture, most of the swamp is too thick and treacherous with deadfall and muckholes for cattle to gain entry, and the effects of grazing are generally restricted to the fringes of the swamp. Besides the Myakka City-Wachula Road already mentioned which crosses the swamp's southern extremity and runs roughly a half mile upland along the swamp's eastern edge, only one other road lies close to the swamp, crossing the Myakka River just as it enters the northeastern arm of Flatford Swamp. The area otherwise remains free of roads, ditches, dikes and landclearing, a phenomenal condition for a Florida wetland in 1977. Testimony to its unaltered aquatic condition is the complete absence of Water Hyacinths.

The entire swamp is posted in the name of D.B. Kibbler, Inc., and shows on the Manatee County tax rolls as being in the ownership of Grace Chemical Corporation .

A field survey of the eastern portion of Flatford Swamp on June 1, 1977 revealed eight types of habitat. They are: Oak Hammock, Mixed Hardwood Swamp, Popash Swamp, Swamp Thickets, Wet Prairie, Freshwater Marsh, Freshwater River, and Freshwater Pond. Bird life is abundant, and we assume that mammals and herps are as well, though it was difficult to find sign of the latter animals in the dense and wet swamp.

The swamp is surrounded by Pine Flatwoods and Dry Prairie - a flat landscape with islands of High Pineland and Scrub and lowlands of Wet Depressions and creek related Hammocks.

Walking from the Flatwoods down into the swamp, in some areas Laurel Oak Hammocks are encountered first, and then long narrow meadows of Wet Prairie habitat grazed by cattle. Notably Iris, Camphorweed, Sawgrass, Water Purslane, and Coreopsis gladiata grow here. Crayfish burrows, Raccoon and Deer tracks were in evidence.

Edging the swamp, both adjacent to Wet Prairie meadows and in places where the Flatwoods descend directly into the swamp, is a thin line of Maples and Wax Myrtle with Carex and Smilax. Popash is distributed continuously throughout the swamp. In many areas it dominates, forming a canopy 15 to 25 feet above the water. Under the canopy there is little understory besides small floating aquatics - Duckweed, Mosquito Fern, and Floating Hearts. The water in these areas averaged about 8 inches in depth.

Freshwater ponds sometimes occur surrounded by Popash Swamp. These characteristically have deeper water, are open to the sun, and are vegetated by a scattering of emergent aquatic plants — Grass, Pickerelweed , Smartweed, Water Purslane. Often a dense thicket of Buttonbush shrubs fills up one side of a pond.

Deeper within the swamp, Popash was present but mixed with other hardwoods - Swamp Bay, Loblolly Bay, Black Tupelo, Sweet Gum Maple, Florida Elm, Dahoon, and Buckthorn. The canopy of the Mixed Hardwood Swamp is higher and more open than that formed by Popash alone. Understory conditions varied widely. In the wettest portions of the swamp (water 1-2 feet deep on June 1) widely scattered individuals of Virginia Willow and Water Hemlock were the only shrubs, and Spatterdock, Water Purslane, and Ribbon Lilies grew in the water. Drier parts of the swamp supported a rich understory of ferns from 4-6 feet tall and thick vines of Smilax and Poison Ivy. Deadfall lay everywhere, highways for herps and small mammals, and a variety of herbaceous plants grew in and around old stumps.

Though we supposedly crossed the Myakka River, no river channel or flow was apparent. The river was swampy at this point; a broad area with slightly deeper water and a more sparse understory than the adjacent swamp.

Numerous birds that rely on Mixed Hardwood Forests were sighted in these swampy areas, including Prothonotary and Parula Warblers, Yellow Throated Vireos, Limkins, Barred Owls, and a Cooper's Hawk. There was evidence of Raccoons, Rabbits and Deer in the Swamp, and Pig Frogs, Leopard Frogs, and Cricket Frogs were calling.

The southern half of the Olgleby Creek (Western) side of Flatford Swamp is a large Freshwater Marsh about one half square mile in area. Emerging from the swamp into the marsh, the characteristic Maple edge was encountered. Wapato, Pickerelweed, and Mock Bishop's Weed growing in 6 inches of water form the backdrop for islandlike impenetrable thickets of shrubby Maples and Buttonbush. Green Herons Rails, Yellow Throated Warblers, and White Eyed Vireos were associated with these thickets.

As the water deepened to 1½ feet, the Wapato and Pickerelweed gave way to Cattails, Spatterdock, and Bladderwort. Small game trails crisscrossed the marsh, evidence of aquatic mammals such as Otter, Water Rats and Raccoons. The marsh is also a likely place for Deer and Bobcat to feed.

Along the eastern edge of the marsh a Wet Prairie habitat similiar to those along the eastern edge of the swamp occurred. It was vegetated in Iris, Spikerush, and Smartweed. The prairie had no standing water, but narrow shallow sandy bottomed channels with flowing water coursed through it. As we followed one streamlet southward, it converged with several others, forming a channel of flowing water 1 foot deep and 10 to 15 feet wide. From the eastern edge of the marsh we could see many wading birds. Wood storks and White Ibis perched in trees around the edge, and Great Blue and Yellow Crowned Night Herons flew overhead.

FLATFORD SWAMP - Common and Scientific Names Mentioned in Text

Common	Scientific
Laurel Oak	*Quercus laurifolia*
Iris --	*Iris hexagona* var. *savannarum*
Camphorweed	*Pluchea purpurascens*
Sawgrass	*Cladium jamaicensis*
Water Purslane	*Ludwigia repens*
	Coreopsis gladiata
Southern Red Maple	*Acer rubrum* var. *tridens*
Wax Myrtle	*Myrica cerifera*
	Carex sp.
Catbrier	*Smilax bona-nox*
Duckweed	*Lemna perpusilla*
Mosquito Fern	*Azolla caroliniana*
Floating Hearts	*Nymphoides aquaticum*
Pickerelweed	*Pontederia lanceolata*
Smartweed	*Polygonum densiflorum*
Buttonbush	*Cephalanthus occidentalis*
Swamp Bay	*Persea palustris*
Loblolly Bay	*Gordonia lasiantha*
Black Tupelo	*Nyssa sylvatica* var. *biflora*
Sweetgum	*Liquidambar styraciflua*
Florida Elm	*Ulmus floridana*
Dahoon	*Ilex cassine*
Buckthorn	*Bumelia reclinata* var. *reclinata*
Virginia Willow	*Itea virginica*
Water Hemlock	*Cicuta mexicana*
Spatterdock	*Nuphar luteum*
Ribbon Lily	*Crinum americanum*
Poison Ivy	*Toxicodendron radicans*
Wapato	*Sagittaria lancifolia*
Mock Bishop's Weed	*Ptilimnium capillaceum*
Cattail	*Typha angustifolia*
Bladderwort	*Utricularia biflora*
Spikerush	*Eleocharis nigrescens*

Species List for 1 June 1977
Not a complete list

Birds

Anhinga
Turkey Vulture
Black Vulture
Cooper's Hawk
Red-shouldered Hawk
Bobwhite
Common Egret
Green Heron
Great Blue Heron
Yellow-crowned Night Heron
Wood Stork
White Ibis
Limpkin
Mourning Dove
Ground Dove
Barred Owl
Pileated Woodpecker
Red-bellied Woodpecker
Yellow-bellied Sapsucker
Blue Jay
Tufted Titmouse
Carolina Wren
White-eyed Vireo
Yellow-throated Vireo
Prothonotary Warbler
Parula Warbler
Yellowthroated Warbler
Yellowthroat
Common Grackle
Cardinal
Rufous-sided Towhee

Mammals

Racoon
Armadillo
[Deer]
Otter
Water rats
Bobcat

Reptiles

Cottonmouth

Amphibians

Cricket frog
Leopard frog
Pig frog

THIS MAP NOT REPRODUCIBLE (MYAKKA CITY NW QUADRANGLE)

ORIGINAL AVAILABLE FROM ARCHBOLD BIOLOGICAL STATION

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TATUM SAWGRASS

Tatum Sawgrass is a well known marsh lying northeast of Upper Myakka Lake in Manatee County. According to U.S.G.S. the area of Tatum Sawgrass is 4,300 acres. Our own computations indicate an area 1,000 acres smaller. We measured that portion of the marsh lying below the 25' contour and north of a dike running eastward from SR 780 in Section 31, T 36 S, R 21 E. Using comparative weights on a Metler Scale to calculate area and also by eyeballing the approximate square miles of the marsh, we arrived at figures of 3476 acres and 3340 acres respectively.

Although the marsh itself is flat and low, lying at 16.5' in elevation, the Tatum Subbasin of the Myakka River Watershed has the highest average slope of the watershed's ten subbasins. This is in spite of the fact that the flat marsh occupies roughly 30% of the subbasin and is included in the slope calculation.

Tatum Sawgrass is then a flat marshland centered in a relatively steep-sided subbasin draining gradually into the Myakka River which courses through the area's south west corner. The marsh is teardrop shaped, broad to the Northeast and tapering to a point in the Southwest. Clay Gully, which cuts off from the Myakka River just upstream from the river's entry to the marsh, has been excavated and deepened, allowing most flow to bypass Tatum Sawgrass entirely. It is only at high water levels that the original channel of the Myakka River carries significant amounts of flow to Tatum Sawgrass. We must conclude that the water found in the marsh originates as rainfall and runoff in the Tatum Sawgrass Subbasin .

Tatum Sawgrass is currently the subject of a U.S.G.S. study designed to evaluate the hydrologic effects of diking in Tatum Sawgrass on the downstream reaches of the Myakka River. The following quote is from the U.S.G.S. progress report on the study, dated June 29, 1976: "Under previous conditions, Tatum Sawgrass served as a large flood detention area for the Myakka River. However, a recently constructed dike system across the mouth of Tatum Sawgrass has virtually eliminated use of the area as a temporary floodwater storage area. As a result, flooding may be increased in the lower Myakka River." The final report should be published "any week now" and preliminary indications are that increases in downstream flood levels are minimal.

The once extensive stands of sawgrass that the marsh was named for have been much reduced. A chunk in the mid eastern section of of Tatum has been improved to pasture for a long time (grassland habitat). In the early 1970's Dewey Oren - Southern Blasting Corporation - diked a long rectangular strip running from North to South in the center of the marsh, and this area is now planted in corn. The northernmost acreage of the strip is vegetated in an old field association of Pokeweed, Dog Fennel, Fiddle Dock, and Erechtites hieracifolia. Since 1973 a dike and canal have been placed around the southernmost square mile of Tatum Sawgrass, and it is safe to assume that the owner, Dewey Oren - Southern Blasting Corporation, will or already has converted it to agricultural purposes

The remaining marshland in Tatum Sawgrass, a quarter section including Cason Lake belonging to Marshall L. Putnal and a half section in the northwestern reach of Tatum Sawgrass belonging to Robert Yarborough, are used as native pasture for cattle. Besides being grazed, the marsh habitat is drier for longer periods of the year due to ditching and diking elsewhere in Tatum. This is evidenced vegetationally by an abundance of young Buttonbush and Southern Red Maple appearing throughout the sawgrass areas, and by Dog Fennel invading a large stand of Wapato.

A field inspection of Robert Yarborough's property on May 31, 1977 found a dry marsh with water levels below the muck soil surface and waist deep water in the ditches and ponds.

Two subtypes of freshwater marsh habitat are evident. One is dominated by Wapato and Smartweed. The other more extensive type is a mosaic of emergent aquatics, each species dominant in its own clump or stand. Islandlike clumps of Cattails or Sawgrass or Buttonbush or Freshwater Cordgrass occur against an alternating backdrop of Mock Bishop's Weed, Spikerush, Pickerelweed , Smartweed, and Prairie Iris. The marsh is important habitat to aquatic animals such as otters, alligators, water rats, snakes, wading birds and waterfowl. Mr. Yarborough informed us that later in the year when there's more water in the marsh, the habitat supports a large population of waterfowl. The numbers of wading birds using the marsh probably increases at this time as well.

Freshwater ponds within the marsh are three to four feet deep and are thickly vegetated by Pickerelweed , Wapato, Spatterdock, and Water Hyacinths. The largest pond in the Tatum area is known as Cason Lake, and according to M.L. Putnal who owns the area, the lake is only three feet deep and goes dry most years. As the rest of the marsh dries up, the ponds become important watering and feeding areas for alligators, amphibians, reptiles, small mammals, deer, bobcat, and wood storks.

The canals and ditches in Tatum Sawgrass are covered uniformly by Water Hyacinths and their associated flora. The spoil dikes are thickets of Dog Fennel and the interface between dike, canal, and marsh appears to be heavily used by wildlife. Raccoon tracks are abundant along the canals. Gator tracks and a gator nest were found adjacent to the dike and canal. Bobcat tracks were in evidence leading away from the canal. We startled a pair of Sandhill Cranes feeding along the edge of a canal. Killdeer and Green Herons nest on the dikes and forage in the marsh. Burrows of small mammals were numerous along the base of the dike. Otter scat was found along game trails atop the dike.

Shrubby heads of Red Maple, Popash, or Willow are scattered throughout the marsh (swamp thicket habitat) providing additional habitat variety, allowing Cardinals, Carolina Wrens, and various warblers to use the marsh. The heads also provide resting areas for mammals.

[redacted]

Tatum Sawgrass is surrounded by Bayheads and Oak Hammocks - areas drier and cooler than the marsh with dense cover. Larger animals, both deer and the predators bobcats, hawks and owls probably use this hammock extensively for cover, making foraging forays and hunting in the marsh.

Common and Scientific Names of Plants Mentioned in Text

Common	Scientific
Pokeweed	*Phytolacca americana*
Dog Fennel	*Eupatorium capillifolium*
Fiddle Dock	*Rumex pulcher*
	Erechtites hieracifolia
Buttonbush	*Cephalanthus occidentalis*
Southern Red Maple	*Acer rubrum* var. *tridens*
Wapato	*Sagittaria lancifolia*
Smartweed	*Polygonum punctatum*
Cattail	*Typha latifolia*
Sawgrass	*Cladium jamaicensis*
Freshwater Cordgrass	*Spartina bakerii*
Mock Bishop's Weed	*Ptilimnium capillaceum*
Spikerush	*Eleocharis nigrescens*
Pickerelweed	*Pontederia lanceolata*
Prairie Iris	*Iris hexagona* var. *savannarum*
Spatterdock	*Nuphar luteum*
Popash	*Fraxinus caroliniana*
Southern Willow	*Salix caroliniana*

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[redacted]

Animals

Species List for 31 May 1977

Birds

Anhinga
Mottled Duck
Turkey Vulture
Black Vulture
Red-shouldered Hawk
Bobwhite
Common Egret
Cattle Egret
Great Blue Heron
Little Blue Heron
Louisiana Heron
Green Heron
Wood Stork
White Ibis
Sandhill Crane
Common Gallinule
American Coot
Killdeer
Mourning Dove
Fish Crow
Carolina Wren
Yellowthroat
Meadowlark
Redwinged Blackbird
Boat-tailed Grackle
Common Grackle
Cardinal

Mammals

River Otter
Bobcat
Raccoon
Gray Squirrel
Florida Water Rat
Armadillo
Opposum
Marsh Rabbit
Whitetail Deer

Reptiles

Alligator

Amphibians

Pig frog
Leopard frog

THIS MAP NOT REPRODUCIBLE (STATE OF FLORIDA, MYAKKA CITY),

ORIGINAL AVAILABLE FROM ARCHBOLD BIOLOGICAL STATION.

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[redacted]

APPENDIX E

A report on freshwater fishes of southwestern peninsular Florida

Prepared by

Carter R. Gilbert
Florida State Museum
Gainesville, Florida

April 1977

April 1977. Prepared for Archbold Biological Station in connection with U.S. Fish and Wildlife Service Contract No. 14-16-0009-77-005.

Freshwater fishes of southwestern peninsular Florida

by

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Florida State Museum
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Introduction

The purpose of this report is to provide data on the freshwater fish fauna of the following eight counties, all of which border, or are adjacent to, the west coast of peninsular Florida: Charlotte, DeSoto, Hardee, Highlands, Hillsborough, Manatee, Polk, and Sarasota. General comments are provided on the taxonomy, biogeography, and ecology of the fishes of the area, and xeroxed or typewritten collection records are included. Comments and corrections regarding the provisional checklist of fishes provided by the Archbold Biological Station are also included.

A table has been compiled, in which the freshwater species that have been recorded from the above eight counties are listed in phylogenetic sequence, together with (a) the major drainage systems and counties from which they have been recorded; (b) an indication of salt tolerance of each family, based on Myers' (1938) classification; and (c) an indication of the typical habitat of each species. Three of the drainage systems included here (Withlacoochee River, Kissimmee River, and Fisheating Creek) extend outside the eight-county area. Species recorded from these systems, but only from counties outside the area under consideration, are so indicated. A number of species normally regarded as marine inhabitants undoubtedly occur in the lowermost freshwater sections of those stream systems under consideration that drain directly into the Gulf of Mexico (i.e., excluding the Kissimmee River and Fisheating Creek). Species that have been recorded one or more times from completely fresh water, and which occur in the eastern Gulf of Mexico, are included in the table, even though they may not actually have been found in any of the systems under consideration. Xeroxed copies are included of three papers, one an unpublished Master's thesis on the fishes of the Hillsborough River system (Barnett, 1972), and the other two dealing with the fishes of the two principal estuaries on the lower west coast of Florida: Tampa Bay (Springer and Woodburn, 1960) and Charlotte Harbor (Wang and Raney, 1971). If desired, a reasonably complete checklist of the inshore marine fishes of the area can be compiled from the last two references. A xeroxed copy has been included of an account of Florida aquatic ecosystems; this was prepared originally for the Florida Audubon Society publication endangered and threatened fish species of the state, and was taken in large part from Berner's (1950) publication on the mayflies of Florida.

The various families in table 1 are indicated by roman numerals I-III, which refers to Myers' (1938) classification of freshwater fishes based on degree of salt tolerance. Primary groups (I) are freshwater fishes that do not occur, and apparently never have occurred, in total sea water; secondary groups (II) are generally freshwater inhabitants, but are tolerant of salt water and frequently occur there; peripheral groups (III) are primarily marine, with certain species entering fresh water on a regular or casual basis.

Records of species utilized in the compilation of this report are from the following museum fish collections: Florida State University, University of Florida (Florida State Museum), Cornell University, Tulane

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University, University of South Florida, and University of Michigan (Museum of Zoology). Xeroxed or typewritten copies of the records from these various collections are included, along with the tabular summary.

None of the species included here are regarded as either endangered or threatened by the Florida Committee on Rare and Endangered Plants and Animals (FCREPA). One species (the Mountain mullet, Agonostomus monticola) has been recorded only a few times from Florida and is considered to be rare in the state.

Museum records are by no means uniformly distributed from the eight-county area or from the various river systems. A large number of collections are available from the Hillsborough drainage, and the fishes of this system were the subject of a recent Master's thesis from the University of South Florida (Barnett, 1972). Numerous collections exist from the Withlacoochee drainage (mostly from the Lake Tsala Apopka area), although not all species have been found in the extreme headwater area, where it enters Polk County. Adequate collections exist from the Peace, Alafia, and Little Manatee systems, but the Manatee and Myakka drainages have been poorly collected. The total numbers of complete collections from the various drainages within the eight-county area are as follows: Withlacoochee River (1), Hillsborough River (23), Alafia River (15), Little Manatee River (10), Manatee River (1), Myakka River (1), Peace River (15), Kissimmee River (9), Fisheating Creek (0). Totals for the respective counties, not broken down by river system, are as follows: Charlotte (6), DeSoto (6), Hardee (2), Highlands (6), Hillsborough (49), Manatee (2), Polk (11), and Sarasota (0). It should be noted that these figures do not take into account the fact that some localities may have been visited more than one time.

General analysis of the Florida freshwater fish fauna

The freshwater fish fauna of Florida is characterized by three main features: (a) its relative impoverishment in terms of numbers of species when compared to some adjacent southeastern states; (b) the large contribution of marine species to the freshwater fauna; and (c) the comparatively large number of exotic species now established in the state's waters. I have recorded a total of 194 species that are either permanent residents of Florida fresh waters of which have been recorded from completely fresh water at one time or another. This compares with over 250 species for such states as Alabama and Tennessee (Smith-Vaniz, 1968; Gilbert, 1970), a difference that becomes all the more significant when one considers that most most of the Alabama fauna, and all of the Tennessee fauna, are comparised of permanent (i.e., non-anadromous) freshwater species, and that very few exotics are involved. In contrast, about 45 percent of the Florida freshwater species occur regularly in salt water or are established exotics.

Of the total of 194 Florida freshwater fishes, 107 are more or less permanently confined to fresh water, and an additional 41 are commonly found there. Eighteen species have been recorded from there only on rare occasions. Twenty-eight exotic species are apparently permanently established (i.e., are reproducing), of which 21 are foreign imports and seven are native to other parts of the United States (Lachner, Robins and Courtenay, 1970; Courtenay, Sahlman, Miley, and Herrema, 1974).

Were it not for the western panhandle of Florida, the total number of freshwater species in the state would be substantially lower than it is. This area contains a number of fishes whose distributional affinities are with the adjacent Mobile Bay drainage. There is a progressive decrease in number of such species as one progresses eastward that is only partly compensated by the addition of eastern forms that reach their western limits of distribution here. After substracting the western Florida species, one finds that only about 65 native non-freshwater fishes in the peninsular area are more or less permanently confined to fresh water.

The impoverishment of the freshwater fish fauna of peninsular Florida is equaled or exceeded by only two other areas of comparable size in eastern United States: New England and the western Great Plains. The factors responsible for this are not the same, however. In New England this is believed to have resulted from the effects of Pleistocene glaciation and the subsequent inability of most fish species to repopulate the area, coupled with the oligotropic nature of the lakes and streams. In the Great Plains it is related to continuing desiccation of the region, coupled with lack of ecological diversity of the larger streams. The Great Plains, in contrast to the other two areas under consideration, has lost many of its native species within the last hundred years or so. In peninsular Florida, this impoverishment has presumably resulted from (a) fluctuations in sea level and periodic instability of the freshwater habitat; (b) a generally uniform type of habitat; and (c) coupled with the above, the inability of most fish species to move into and through the area from their centers of origins and abundance in southeastern United States (see Burgess, Gilbert, Guillory, and Taphorn [1977] for further discussion). Another factor, presumably less important than the above, is the fact that the sandy, rather sterile soil of much of peninsular Florida is probably reflected in a somewhat lower species diversity in the aquatic ecosystem than would otherwise be the case.

In terms of group composition, the freshwater fish fauna of peninsular Florida is characterized by small numbers of species of most families compared to the southeastern United States in general. The southern half of the peninsula (in the area south of a line extending eastward from the Tampa area) is especially impoverished. This phenomenon is best demonstrated by four families that contribute a high percentage of the fish species of eastern North America, namely the Cyprinidae (minnows), Catostomidae (suckers), Ictaluridae (freshwater catfishes), and Percidae (perches). For two other families (the Centrarchidae [sunfishes and black basses] and Cyprinodontidae [killifishes and topminnows]) the situation is reversed, and Florida in general, and peninsular Florida in particular, have an unusually high percentage of the total species occurring in eastern North America. As a matter of fact, Florida contains more native species of Cyprinodontidae than any other state and more native centrarchids than any state except Alabama. The following figures illustrate these points (figures refer, respectively, to number of species from each group in eastern United States and Canada; species in Florida; species in the eight-county area here considered; and [beneath] the percentage of eastern North American species in this area):

Cyprinidae	Catostomidae	Ictaluridae	Percidae	Centrarchidae
183-27-6	37-8-1	39-9-5	148-15-2	34-21-12
(3.3%)	(2.7%)	(12.8%)	(1.4%)	(35.3%)

Cyprinodontidae
(partly or entirely freshwater species only)

29-13-10
(34.5%)

The above differences in numbers and percentages for the various families are attributable to a combination of diverse zoogeographical histories and different ecological preferences of the included species. With few exceptions, the North American percid species are riffle inhabitants, and require fast-flowing, well-oxygenated water. The same is true of many of the catostomids and cyprinids, although to a lesser degree than for the percids. Ictalurids as a group are rather sharply divided ecologically between those inhabiting quiet stagnant waters and those preferring fast-flowing waters, although numerically those species inhabiting the latter type of situation predominate throughout North America~~n~~ (though not in Florida). Most centrarchid species, on the other hand, occur in quiet, often weedy waters such as those characterizing much of peninsular Florida. Thus, for the above five families, the small number of species in peninsular Florida appears in large degree to have an ecological basis. For the cyprinodontids, however, their unusual abundance in peninsular Florida seems to be more closely associated with their past zoogeographical and evolutionary histories. Species in this family are ~~are~~ more salt tolerant than are species of the other five groups being considered, even if their geographic distributions are completely restricted to fresh water. Three of the ten peninsular cyprinodontid species, in fact, are more frequently found in brackish than fresh water (*Fundulus confluentus*, *Lucania parva*, and *Cyprinodon variegatus*). The distributions of two species (*Fundulus seminolis* and *Jordanella floridae*) are entirely confined to Florida and largely limited to the peninsular area; and the distributions of three others (*Fundulus cingulatus*, *Lucania goodei*, and *Leptolucania ommata*) extend a short distance outside of Florida, but are still

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centered in the peninsula. All these factors suggest that much of the Florida cyprinodontid fauna has been derived directly from marine ancestors that invaded the largely uninhabited fresh waters of the peninsula in times past and there evolved into distinct species. In this regard it should also be mentioned that certain Florida members of the Cyprinodontidae, as well as of the closely related Poeciliidae, have closely related forms in Yucatan (e.g., the closest relative of the monotypic *Jordanella floridae* is another monotypic genus and species, *Garmanella pulchra*, from Yucatan).

Despite the small number of species in peninsular Florida of the other five families, there are nevertheless two examples of well-defined, endemic subspecies in this area. The Florida pugnose minnow (*Notropis emiliae peninsularis*) and Florida largemouth bass (*Micropterus salmoides floridanus*) range northward to the St. Johns and Withlacoochee Rivers, with populations in the adjacent Suwannee and St. Marys systems consisting of intergrades between these and the typical subspecies (Bailey and Hubbs, 1949; Gilbert and Bailey, 1972). Disjunct populations of four species (Bluenose shiner, *Notropis welaka*; Coastal shiner, *Notropis cummingsae*; Snail bullhead, *Ictalurus brunneus*; and Tessellated darter, *Etheostoma olmstedi*) occur in the lower St. Johns River system. In each case the closest adjacent populations are at least two river systems removed, and in no case has one of these disjunct populations differentiated to the subspecies level (Burgess, Gilbert, Guillory, and Taphorn, 1977). The historical factors resulting in isolation of these four species in the St. Johns system are believed to be different from those leading to isolation and subsequent differentiation of the peninsular populations of the Pugnose minnow and Largemouth bass (Burgess and Franz, in press).

It has long been assumed that freshwater species occurring in quiet-water situations of peninsular Florida are more or less generally distributed, inasmuch as the habitat is rather uniform and drainage divides are poorly defined and easily breached. Although a number of peninsular species do show generalized distribution patterns, it is now also clear that others do not, and they are missing from river systems in which they might logically be expected to occur. Gaps exist so far as confirmed occurrence of different species in the various river systems are concerned. Many of these undoubtedly are artifacts of collecting, which will be rectified with further work. On the other hand, the consistent absence from the well-surveyed Hillsborough River system of such fishes as *Notropis emiliae peninsularis*, *Enneacanthus obesus*, *Percina nigrofasciata*, *Fundulus cingulatus*, and (for all practical purposes) *Leptolucania ommata* strongly suggests that this is a natural situation. When generally common and easily collected species fail to appear in collections from several adjacent river systems in a row, one may suspect that their absence there is real, particularly if suitable habitat is present. Thus, the absence from all west coast drainages south of the Hillsborough of such species as *Aphredoderus sayanus*, *Fundulus notti lineolatus*, *Esox americanus*, and *Esox niger*; and from all streams between the Peace and Withlacoochee systems of *Notropis emiliae peninsularis* are believed to represent natural situations.

Amia calve has not been recorded south of the Hillsborough system on the west coast of Florida, but occurs in the Kissimmee drainage and is also known from the Everglades. As indicated above, *Esox americanus*, *Esox niger*, and *Fundulus notti lineolatus* have also not been found south of the Hillsborough drainage; they also enter the Kissimmee drainage, but, unlike *Amia calva*, do not range south into the Everglades. Ager (1971), however, reported both species of *Esox* from Lake Okeechobee. *Percina nigrofasciata* apparently occurs in no coastal drainage south of the Suwannee, but is found in the Kissimmee drainage as far south as Highlands County. *Notropis emiliae peninsularis* and *Ictalurus punctatus* display similar distribution patterns to the two species of *Esox* and *F. notti lineolatus*, except that they have moved westward into the Peace (and possibly also the Myakka) drainage.

In summary, 89 fish species are of potential or confirmed occurrence in fresh waters of the eight-county area under consideration, of which there are confirmed freshwater records for 65 species. Thirty-four of the 85 species are essentially marine or brackish-water inhabitants, and of these there are confirmed records for 15 species. Although such species as *Trinectes maculatus*, *Mugil cephalus*, *Lucania parva*, and *Menidia beryllina* are included in the marine category, they are all common in Florida fresh waters, and in this state at least are regarded as freshwater species as much as marine species. Two species (*Fundulus confluentus* and *Cyprinodon variegatus*) for which there are not yet confirmed freshwater records occur in such situations with such regularity that they will undoubtedly be added to the list eventually. Three species (*Clarias batrachus*, *Tilapia aurea*, and *Tilapia melanotheron*) are introduced exotics.

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APPENDIX F

A report on distributions of larval Chironomidae in the Peace and Alafia basins

Prepared by

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April 1977

1406

DISTRIBUTIONS OF LARVAL CHIRONOMIDAE IN THE PEACE AND ALAFIA BASINS, FLA.

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April 1977

Prepared for Archbold Biological Station in connection with
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1407

I. DISTRIBUTION OF CHIRONOMIDS IN THE PEACE BASIN

TAXON	STATION	COUNTY
Ablabesmyia aspera (Roback)	P-8	Polk
Ablabesmyia janta (Roback)	P-17	Hardee
Ablabesmyia mallochi (Walley)	P-55	Polk
Ablabesmyia ornata Beck & Beck	Green Swamp	Polk
Ablabesmyia peleensis (Walley)	P-17	Hardee
Ablabesmyia philosphagnos Beck & Beck	Green Swamp	Polk
Chironomus attenuatus (Walker)	widespread	----
Chironomus crassicaudatus (Malloch)	Chain of Lakes	Polk
Cladotanytarsus sp	P-54	Polk
Cladotanytarsus sp	Eagle Lake	Polk
Clinotanypus sp	widespread	Polk
Conchapelopia sp	P-40	Polk
Corynoneura taris Roback	Lake Tracy	Polk
Corynoneura taris Roback	P-18	Hardee
Cricotopus bicinctus (Meigen)	widespread	Polk
Cricotopus remus Sublette	Lake Howard	Polk
Cricotopus remus Sublette	Lake Cannon	Polk
Cricotopus remus Sublette	Lake Tracy	Polk
Cryptotendipes sp Beck & Beck	P-8	Polk
Cryptotendipes sp Beck & Beck	P-55	Polk
Cryptotendipes sp Beck & Beck	Lake Martha	Polk
Endchironomus nigricans (Johannsen)	Lake Cannon	Polk
Eukiefferiella sp	P-7	Hardee
Eukiefferiella sp	P-18	Hardee
Glyptotendipes paripes (Edwards)	widespread	----
Goeldichironomus holoprasinus (Goeldi)	P-12	Polk
Goeldichironomus holoprasinus (Goeldi)	P-54	Polk
Goeldichironomus holoprasinus (Goeldi)	P-57	Polk
Goeldichironomus holoprasinus (Goeldi)	Lake Cannon	Polk
Guttipelopia currani Beck & Beck	Green Swamp	Polk
Harnischia sp	P-16	Polk
Harnischia amachaerus (Townes)	P-16	Polk
Harnischia amachaerus (Townes)	McCollough Creek	Polk
Harnischia boydi (Beck)	Lake Ina	Polk
Harnischia galetor Townes	Lake Ina	Polk
Kiefferulus dux (Johannsen)	P-54	Polk
Labrundinia becki Roback	P-7	Hardee
Labrundinia pilosella (Loew)	P-7	Hardee
Labrundinia virescens Beck & Beck	P-58	Polk
Labrundinia virescens Beck & Beck	P-18	Hardee
Larsia sp	widespread	
Nimbocera sp	Roadside ponds	Hardee
Orthocladius annectens Saether	P-40	Polk
Parachironomus carinatus (Townes)	Lake Cannon	Polk

I. DISTRIBUTION OF CHIRONOMIDS IN THE PEACE BASIN

TAXON	STATION	COUNTY
Parachironomus directus (Dendy & Sublette)	Lake Ina	Polk
Parachironomus directus (Dendy & Sublette)	Lake Howard	Polk
Parachironomus hirtalatus (Beck & Beck)	Lake Tracy	Polk
Parachironomus monochromus (Wulp)	Lake Howard	Polk
Parachironomus sublettei (Beck)	Lake Ina	Polk
Parachironomus sublettei (Beck)	Abandon mine pit near Bartow AB	Polk
Paracladopelma sp	P-12	Polk
Paralauterborniella nigrohalteralis (Malloch)	P-8	Polk
Paratendipes sp	Lake M^{c}Cloud	Polk
Paratendipes sp	P-55	Polk
Pentaneum inculta Beck & Beck	P-17	Hardee
Pentaneum inculta Beck & Beck	P-8	Polk
Pentaneum inculta Beck & Beck	P-55	Polk
Pentaneum inculta Beck & Beck	P-57	Polk
Polypedilum fallax (Johannsen)	Lake Tracy	Polk
Polypedilum fallax (Johannsen)	P-18	Hardee
Polypedilum halterale (Coquillett)	widespread	----
Polypedilum illinoense (Malloch)	widespread	Polk & Hardee
Polypedilum scalaenum (Shrank)	P-54	Polk
Polypedilum scalaenum (Shrank)	P-57	Polk
Polypedilum sp	widespread	----
Procladius sp	widespread	----
Pseudochironomus sp	P-2	DeSoto
Pseudochironomus sp	P-3	DeSoto
Pseudochironomus sp	Lake Martha	Polk
Pseudochironomus sp	Eagle Lake	Polk
Rheocricotopus robacki (E.C. Beck)	Lake Hancock Canal	Polk
Rheotanytarsus exiguus Johannsen	widespread	----
Stictochironomus sp	Eagle Lake	Polk
Stictochironomus sp	Lake Martha	Polk
Stictochironomus sp	P-2	DeSoto
Tanypus sp	P-9	Polk
Tanypus sp	US 17 (borrow pit)	Hardee
Tanypus carinatus Sublette	P-12	Polk
Tanypus carinatus Sublette	P-16	Polk
Tanypus neopunctipennis Sublette	P-9	Polk
Tanypus neopunctipennis Sublette	P-12	Polk
Tanypus stellatus Coquillett	Lake Ina	Polk
Tanytarsus sp	widespread	Polk
Thienemanniella xena Roback	widespread	Polk
Tribelos fuscicornis (Malloch)	Green Swamp	Polk

THIS MAP NOT REPRODUCIBLE (PEACE RIVER AND VICINITY, FLORIDA).

ORIGINAL AVAILABLE FROM ARCHBOLD BIOLOGICAL STATION.

II. DISTRIBUTION OF CHIRONOMIDS IN THE ALAFIA BASIN

TAXON	STATION	COUNTY
Ablabesmyia aspera	A-20	Hillsboro
A. auriensis (Roback)	A-20	Hillsboro
A. auriensis	A-4	Hillsboro
A. janta	A-20	Hillsboro
A. mallochi	A-20	Hillsboro
Chironomus attenuatus	widespread	Hillsboro
C. stigmaterus Say	A-4	Hillsboro
Clinotanypus sp.	A-17	Hillsboro
Clinotanypus sp.	A-18	Hillsboro
Conchapelopia sp.	A-18	Hillsboro
Conchapelopia sp.	A-20	Hillsboro
Cricotopus bicinctus	A-3	Hillsboro
Cricotopus bicinctus	A-22	Polk
Cricotopus bicinctus	A-20	Hillsboro
Cryptochironomus fulvus	widespread	Hillsboro
Cryptotendipes sp.	A-20	Hillsboro
Eukiefferiella sp.	A-4	Hillsboro
Goeldichironomus holoprasinus	A-22	Polk
Goeldichironomus holoprasinus	A-28	Hillsboro
Labrundinia becki	A-17	Hillsboro
L. becki	A-20	Hillsboro
L. floridana Beck & Beck	A-4	Hillsboro
L. pilosella	A-17	Hillsboro
L. pilosella	A-20	Hillsboro
Paralauterborniella nigrohalteralis	A-20	Hillsboro
Pentaneura inculta	A-3	Hillsboro
Pentaneura inculta	A-4	Hillsboro
Polypedilum illinoense	A-4	Hillsboro
Polypedilum illinoense	A-22	Polk
P. scalaenum	A-20	Hillsboro
P. scalaenum	Lithia Spring	Hillsboro
P. sp	widespread	Hillsboro
P. sp.	widespread	Polk
Procladius sp.	widespread	Polk
Procladius sp.	widespread	Hillsboro
Psectrocladius elatus Roback	A-18	Hillsboro
Psectrocladius elatus	A-20	Hillsboro
Rheocricotopus robacki	A-18	Hillsboro
Rheocricotopus robacki	A-20	Hillsboro
Rheotanytarsus exiguus	widespread	Hillsboro
Rheotanytarsus exiguus	widespread	Polk
Stenochironomus hilaris (Walker)	A-20	Hillsboro
Tanytarsus sp.	widespread	Hillsboro
Tanytarsus sp.	widespread	Polk
Thienemanniella xena	widespread	Polk
Thienemanniella xena	widespread	Hillsboro
Tribelos fuscornis	A-20	Hillsboro
Tribelos fuscornis	Paynes Creek	Hardee

THIS MAP NOT REPRODUCIBLE (ALAFIA RIVER AND VINCINITY).

ORIGINAL AVAILABLE FROM ARCHBOLD BIOLOGICAL STATION.

[redacted]

RELATIVE ABUNDANCE

RARE: this term is not used in the sense of "Rare or Endangered Species", but rather to cover the following:

1. A taxon at an extreme of its range, found only in a small area of one of the basins. (*Nimbocera* sp.)
2. A taxon occupying a niche not occurring repetitively in the basins. (*Cryptotendipes* sp.)
3. A taxon for which we do not know the specific minor habitat. (*Guttipelopia currani*)

OCCASIONAL: taxa found at several stations within a basin but occurring consistently. (*Cladotanytarsus* sp.)

COMMON: taxa found at most stations in all types of water. (*Chironomus attenuatus*)

III. RELATIVE ABUNDANCE

RARE

Ablabesmyia philosphagnos
Cryptotendipes sp.
Guttipelopia currani
Harnischia boydi
Nimbocera sp.
Orthocladius annectens
Paracladopelma sp.
Paratendipes sp.
Pseudochironomus sp.

OCCASIONAL

Ablabesmyia aspera
A. mallochi
Chironomus stigmaterus
Cladotanytarsus sp.
Corynoneura taris
Cricotopus remus
Endochironomus nigricans
Eukiefferiella sp.
Harnischia amachaerus
H. qaleator
H. sp.
Kiefferulus dux
Labrundinia floridana
L. Pilosella
L. virescens
Parachironomus carinatus
P. directus
Pentaneura inculta
Stictochironomus sp.

COMMON

Ablabesmyia janta
A. ornata
A. peleensis
Chironomus attenuatus
C. crassicaudatus
Cladotanytarsus sp.
Conchapelopia sp.
Cricotopus bicinctus
Cryptochironomus fulvus

[redacted]

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Glyptotendipes paripes
Goeldichironomus holoprasinus
Labrundinia becki
Larsia sp.
Parachironomus lirtalatus
P. monochromus
P. sublettei
Paralauterborniella nigrohalteralis
Polypedilum fallax
P. halterale
P. illinoense
P. scalaenum
P. sp.
Procladius sp.
Rheocricotopus robacki
Rheotanytarsus exignus
Tanypus carinatus
T. neopunctipennis
T. stellatus
T. sp.
Tanytarsus sp.
Thienemanniella xena
Tribelos fuscicornis

CLASSIFICATION WITH REGARD TO POLLUTION

CLASS I. is comprised of those organisms which have been found to tolerate no appreciable organic pollution, the more sensitive forms. The presence of Class I organisms is considered indicative of the fact that the water in which they are found is clean.

CLASS II. organisms are those which tolerate a moderate amount of pollution, but do not tolerate conditions approaching or reaching the anaerobic. Thus the presence of Class II organisms may be interpreted to mean that the area in question is not heavily polluted.

CLASS III. contains organisms which have been found in heavily polluted areas. It should be understood that no organism in Class III may be considered indicative of pollution. These organisms may be found in clean waters, moderately polluted waters, or grossly polluted waters.

CLASS IV. Not applicable.

CLASS V. comprises those organisms which have not been otherwise classified due to such factors as too few records, lack of knowledge of their physiological requirements, or organisms for which identifications are pending. This class is in essence the reservoir from which future representatives of the first three classes will be derived.

[redacted]

IV. POLLUTIONAL CLASSIFICATION

CLASS I

Ablabesmyia aspera
A. auriensis
A. mallochi
A. ornata
Corynoneura taris
Cricotopus bicinctus
Cryptotendipes sp.
Eukiefferiella sp.
Labrundinia becki
L. floridana
L. virescens
Orthocladius annectens
Paralauterborniella nigrohalteralis
Pentaneura inculta
Polypedilum fallax
P. halterale
Psectrocladius elatus
Rheocricotopus robacki
Rheotanytarsus exiguus
Stenochironomus hilaris
Stictochironomus sp.
Thienemanniella xena
Tribelos fuscicornis

CLASS II

Ablabesmyia janta
A. peleensis
Cladotanytarsus sp.
Clinotanypus sp.
Polypedilum illinoense
Procladius sp.

CLASS III

Chironomus attenuatus
C. crassicaudatus
C. stigmaterus
Cryptochironomus fulvus
Glyptotendipes paripes
Goeldichironomus holoprasinus
Kiefferulus dux
Polypedilum scalaenum
Tanypus carinatus
T. neopunctipennis
T. stellatus
T. sp.

CLASS V

Ablabesmyia philosphagnos
Conchapelopia sp.

CLASS V (cont.)

Cricotopus remus
Endochironomus nigricans
Guttipelopia currani
Harnischia amachaerus
H. boydi
H. galeator
H. sp.
Labrundinia pilosella
Larsia sp.
Nimbocera sp.
Parachironomus carinatus
P. directus
P. hirtalatus
P. monochromus
P. sublettei
Paracladopelma sp.
Paratendipes sp.
Polypedilum sp.
Pseudochironomus sp.
Tanytarsus sp.

[redacted]

V. DISTRIBUTION BY WATER TYPES

LOTIC

Ablabesmyia auriensis
A. ornata
Corynoneura taris
Cricotopus bicinctus
Cryptotendipes sp.
Eukiefferiella sp.
Labrundinia becki
Orthocladius annectens
Paracladopelma sp.
Paratendipes sp.
Pentaneura inculta
Polypedilum fallax
Psectrocladius elatus
Rheocricotopus robacki
Rheotanytarsus exiguus
Stenochironomus hilaris
Stictochironomus sp.
Thienemanniella xena
Tribelos fuscicornis

LENITIC

Ablabesmyia philosphagnos
Chironomus attenuatus
C. crassicaudatus
C. stigmaterus
Cladotanytarsus sp.
Glyptotendipes paripes
Guttipelopia currani
Harnischia boydi
H. galeator
Kiefferulus dux
Nimbocers sp.
Parachironomus directus
Procladius sp.
Tanypus carinatus
T. neopunctipennis
T. sp.

UBIQUITOUS

Ablabesmyia aspera
A. janta
A. mallochi
A. peleensis
Clinotanypus sp.
Conchapelopia sp.
Cricotopus remus
Cryptochironomus fulvus
Endochironomus nigricans

UBIQUITOUS (cont.)

Goeldichironomus holoprasinus
Harnischia amachaerus
Labrundinia floridana
L. pilosella
L. virescens
Larsia sp.
Parachironomus carinatus
P. hirtalatus
P. monochromus
P. sublettei
Paralauterborniella nigrohalteralis
Polypedilum halterale
P. illinoense
P. scalaenum
P. sp.
Pseudochironomus sp.
Tanypus stellatus
Tanytarsus sp.

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APPENDIX G

A report on the activities of the Bureau of Environmental Protection of the Florida Game and Fresh Water Fish Commission in connection with phosphate mining and reclamation

Prepared by

D. Terry Gilbert
Bureau of Environmental Protection
Florida Game and Fresh Water Fish Commission
Vero Beach, Florida

July 1977

July 1977. Prepared for Archbold Biological Station in connection with [redacted]
U.S. Fish and Wildlife Contract No. 14-16-0009-77-005.

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FLORIDA GAME AND FRESH WATER FISH COMMISSION

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H.E. WALLACE, Deputy Director
R.M. BRANTLY, Deputy Director

FARRIS BRYANT BUILDING
620 South Meridian Street
Tallahassee, Florida 32304

P. O. Box 1840
Vero Beach, Florida 32960
July 6, 1977

Mr. James N. Layne
Executive Director
Archbold Biological Station
Route 2, Box 180
Lake Placid, Florida 33852

Dear Mr. Layne:

The Bureau of Environmental Protection of the Florida Game and Fresh Water Fish Commission reviews and comments to the Department of Environmental Regulation and United States Army Corps of Engineers on phosphate related dredge and fill permits. Our agency also assesses fish and wildlife impacts in new mining areas and recommends mitigation measures to increase the wildlife habitat carrying capacity of reclaimed land through total reclamation planning. In this regard, we comment to the Central Florida Regional Planning Council, the Division of State Planning, and individual phosphate companies.

During the past year we have surveyed future mining areas, active mine sites and reclamation projects on company lands owned by Beker, Brewster, Mobil Chemical, Agrico, International Minerals and Chemical Corporation, W. R. Grace, CF Industries, Swift Chemical Company, Borden, Mississippi Chemical Corporation, and Phillips Petroleum.

While our surveys in Polk, Hillsborough, Manatee, Hardee and DeSoto Counties show that many of the vegetative communities in the proposed mining areas have been modified in the past in order to support cattle ranching and citrus operations, this area nevertheless provides essential habitat for many wildlife species. A tentative list we compiled shows that the following numbers of species may use various habitats in the area: 34 mammals, 173 birds, 73 amphibians and reptiles, and 53 fishes.

It has been our position that mining or disturbance to sensitive wetland areas such as primary or secondary tributaries of regional streams and their associated hydric swamp forests and fresh water marshes results in permanent habitat losses and drastic population reductions for many wildlife species of the area. The floodplain areas of these streams and associated shallow ponds are vegetated by various hydric hardwoods, oaks, and marsh plants which have evolved to function in a regime of periodic inundation. They are important to both wildlife and man as they provide improved nutrient assimilation, water recharge, and an important buffer between streams and phosphate mining activities in adjacent upland areas. They also furnish escape cover, nesting and roosting areas, and lanes of travel for many kinds of wildlife which would be rare or absent if this vegetative type were lacking. This is especially true for many wildlife species which require several habitat types in close proximity within the home range.

Also, temporary and permanent stagnant water ponds and marshes found in the region associated with the hydric swamp forests tend to increase diversity and provide good quality habitat for wildlife. These areas typically fluctuate on an annual basis depending on the amount of rainfall. Populations of small forage fishes, invertebrates, and amphibians expand during high water periods, and provide a concentrated food source during receding water levels.

In our opinion, current county reclamation policies sometimes encourage the reclamation of land suitable for urban development or various agricultural uses. In the past, the end result of the reclamation process has been a transformation of mined land, irregardless of the vegetative associations which naturally occurred there, into two generalized land forms consisting of flat, well drained land conducive to pasture and citrus operations, and extensive simple lake systems with rolling topography. Mowing and grazing tends to hold these upland areas in a herbaceous stage and precludes normal vegetative succession to more complex habitat. Therefore the loss of regional wetlands and other essential upland habitat types is not compensated by the creation of extensive lake systems and dry upland pasture areas as presently designed.

We feel that research is needed to improve techniques for restoration of fish and wildlife habitat on mined land. There is a need to determine economical techniques of re-establishing certain plant community types including hydric hardwoods, mesic hardwoods, xeric hardwoods and freshwater marsh systems apart from, and in conjunction with restoring small vegetated floodplains on mined land.

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If these techniques can be developed, new reclamation options would be available to allow companies to mine with reduced environmental impact on the natural systems of the region. These procedures would also provide additional mitigation measures to facilitate easier permitting of dredge and fill projects and new mining proposal evaluations. Some of these research needs are:

1. How to establish and maintain desirable marsh plant species in a reclaimed freshwater marsh system.
2. Methods of establishing and propagating desirable reclaimed lake littoral zone vegetation.
3. Methods to economically and successfully establish upland trees and upland plant communities on reclaimed land, either by direct seeding or planting.
4. Methods of re-establishing hydric vegetation and meandered small stream channels in disturbed or obliterated floodplains.
5. Determine the natural plant and animal succession on reclaimed land which is not put to use, and find useful methods to accelerate vegetative succession.
6. Methods and management procedures for converting old inactive clay settling areas to freshwater marsh habitat.
7. The number of acres, habitat quality and wildlife use of orphaned or unreclaimed mining land and identification of reclamation needs.

In order to mitigate some of the impacts associated with mining, we offer the following recommendations which are intended to accelerate natural succession on reclaimed land to improve fish and wildlife habitat in the confines of current reclamation procedures.

Lake Development

Lakes could be designed for the creation of additional areas of littoral zone and aquatic wildlife habitat. Specific optimum design criteria and management for these lakes and associated aquatic system could be as follows:

[redacted]

(1) The body of water needs to have a littoral zone of six feet deep or less in 25 percent or more of the surface area. The rest of the surface area of the water body needs to be less than 15 feet deep, preferably holding deep water over 9 feet to a minimum with a preferred overall average water depth of 6 to 8 feet. This design encourages and promotes user safety, reproduction of fish, growth of desirable aquatic plants, and balanced evaporation rates.

(2) The lake's littoral zone should slope gently at a 6:1 ratio, grading to a 3:1 slope for optimum fish reproduction, safety and aquatic weed control.

(3) A green belt of vegetation, especially mast producing trees, is beneficial around the lake shoreline to reduce siltation from turbid runoff which reduces growth and reproduction of fish and other aquatic life. This over-story and understory vegetation would also provide feeding areas, escape cover, roosting and nesting areas for birds and mammals.

Our agency strongly recommends against the use of exotic tree species in the reclamation planting program. Specifically to be avoided are Australian pine (*Casuarina equisetifolia*), Brazilian pepper tree (*Schinus terebinthifolius*), melaleuca (*Melaleuca quinquenervia*), eucalyptus (*Eucalyptus* sp.), and others which have in some cases proven to be obnoxious pest plants providing little habitat value for native wildlife. More importantly, these species can sometimes be very prolific and replace native vegetation which is used and preferred by Florida wildlife species. Therefore, tree species selected for planting should be native and planted in ecologically adaptable situations where good survival and maximum benefits will be realized.

Several species which could be planted adjacent to the waters edge are red maple, (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*), water oak (*Quercus nigra*), sweetbay (*Magnolia virginiana*), diamond leaf oak, (*Q. laurifolia*), bald cypress (*Taxodium distichum*), and blackgum (*Nyssa biflora*). Landward areas would support more upland species of pine and oaks including slash pine (*Pinus elliottii*),

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longleaf pine (P. palustris), laurel oak (Q. hemispherica), live oak (Q. virginiana), black cherry (Prunus serotina) and others. The planting of enough trees to insure species establishment would provide a future seed source for accelerated natural succession.

(4) Normal fluctuation of reservoir water levels is necessary because it expands and concentrates aquatic food organisms, provides for a dynamic aquatic community, and increased productivity. Water levels need to be naturally or sometimes artifically fluctuated so that they simulate natural conditions (lowest in spring, highest in early fall). Drawdowns, when needed for fish and waterfowl purposes, should not be more frequent than once a year or extend throughout the spawning season of desirable fish.

(5) Instead of lake systems dominated by rank growths of cattail (Typha latifolia), water hyacinth (Eichhornia crassipes), hydrilla (Hydrilla verticillata), etc. a diversity of aquatic plant species including the introduction of maidencane (Panicum hemitomon) within the littoral zone should be encouraged for improved forage food species, cover, improved fish population and water quality. More on-site study is needed to determine adequate propagation and management procedures for these aquatic plants.

Upland Areas

Most upland areas we have surveyed thus far have been reclaimed as pastureland associated with lakes of various sizes. These large open areas of improved pasture offer little food or cover for most wildlife species. Large uninterrupted areas of improved pasture could be broken up by clumps of scattered trees planted at a low density which would not materially lower forage production but provide shade and weather protection for cattle and some wildlife habitat. Adaptable species include slash pine, longleaf pine, live oak and others. Those upland areas in drainage paths, or where the land surface slopes to a lake, would be an excellent area for xeric or mesic woodlands consisting of pines and oaks as part of the reclamation program.

Aside from their aesthetic value, these planted upland areas in the lake's watershed serve to stabilize the soil and prevent erosion. Overall, they increase the wildlife habitat carrying capacity of the land and real estate values.

Areas along fence rows and roads could be spared from mowing and allowed to re-vegetate naturally providing excellent habitat for small game and non-game species.

When sand tailings are not used as fill for reclamation, they are sometimes pumped and deposited as sand ridges covering 3 to 15 acres or more. These barren areas show extremely slow natural revegetation and are somewhat overlooked in reclamation attempts. We feel that these areas, after a period of compaction, will support native vegetation which is adaptable to dry, stressful habitats. These species include sand pine (*P. clausa*), sand live oak (*Q. geminata*), Chapman's oak (*Q. chapmanii*), myrtle oak (*Q. myrtifolia*), turkey oak (*Q. laevis*), and herbaceous forms characteristic of this habitat. This would provide a vegetative start for habitat well suited for several forms of birds, mammals and reptiles adapted to this unique community. The first sand pine seedlings should be planted around the toe of the downhill slope to insure establishment. Further study will determine procedures of hay mulching, etc. to reduce evaporation and permit vegetation establishment.

Clay Settling Areas

Settling ponds used to store and consolidate waste clays are difficult and costly to restore, while the end production of present reclamation efforts is of little value to wildlife. Continuing studies will hopefully provide better methods of waste clay disposal and allow below ground storage which will make the overall phosphate mining procedure more environmentally acceptable. Consideration should be given to the reclamation or retention of some of the older clay settling areas as freshwater marsh habitat. Further indepth study is needed to determine certain management criteria such as the period of years for adequate crust development after the settling area becomes inactive, necessary water control structures, and correct water manipulation procedures to encourage desired aquatic vegetation. Procedures may also be needed to further place these areas in an inert state preventing the possibility of clay flowage.

Some of the clay settling ponds we have surveyed were utilized by appreciable numbers of all the common herons and egrets, white ibis, wood storks, lesser scaup, blue-winged teal, Florida duck, shoveler, American widgeon, ring-necked duck, hooded merganser, anhinga, double-crested cormorant, pied-billed grebe, red-shouldered hawk, osprey, marsh hawk and many kinds of shorebirds. Mammals noted include raccoons, marsh rabbits and river otter. Those older settling areas which meet certain established criteria could be productive game and non-game wildlife habitat if managed properly.

[redacted]
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In conclusion, we feel that reclamation habitat types are presently simple systems compared to the natural habitats being mined. Habitat loss in the region for species such as deer, turkey, hog and many other woodland dependent birds and mammals has probably resulted in decreased numbers of these animals. At the same time, mining related disturbances and the creation of additional water areas has resulted in an apparent expansion of habitat favored by aquatic oriented species. We feel that due to the total land area involved, changes in revegetation procedures on some of these reclaimed areas would enormously benefit wildlife, improve groundwater recharge, and improve water quality. A multiple land use approach to reclamation planning which serves to protect essential wetlands and balance reclamation types to include agricultural lands, lakes, and woodlands will serve to protect the natural systems of the region.

I hope this information if of some help to you in your study. If we can further assist you in any way, please do not hesitate to contact us.

Sincerely,

Terry

D. Terry Gilbert
Environmental Specialist
Bureau of Environmental Protection

DTG/rs
CC: Dan Dunford, FGFWFC
Arch Mehrhoff, USFWS

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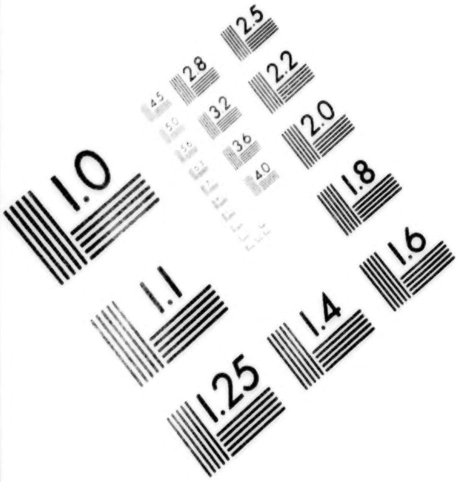

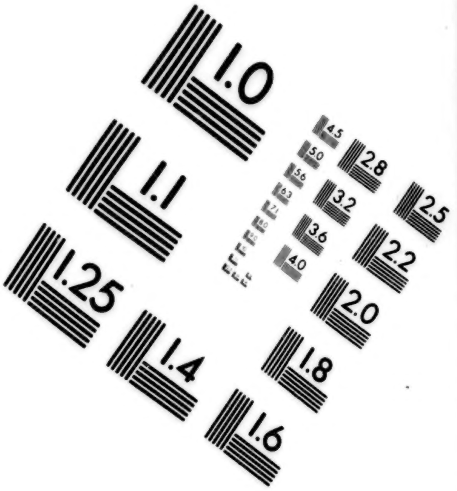

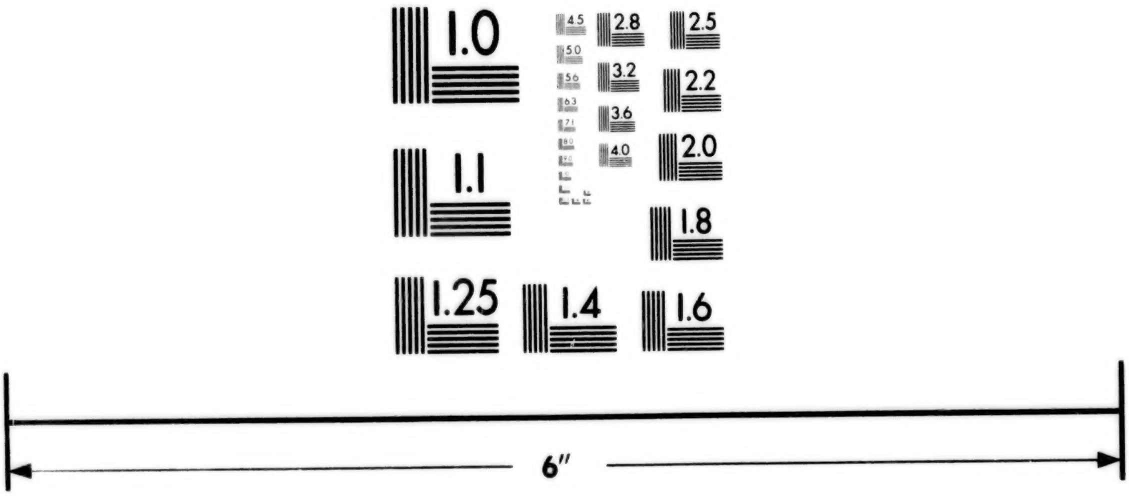

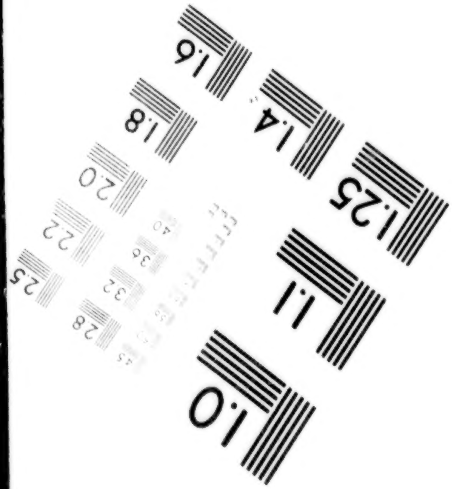

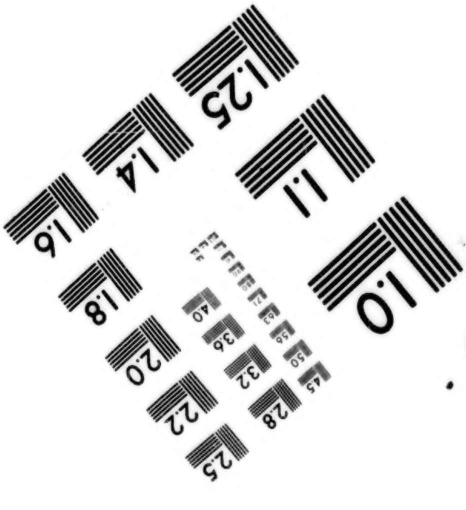

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